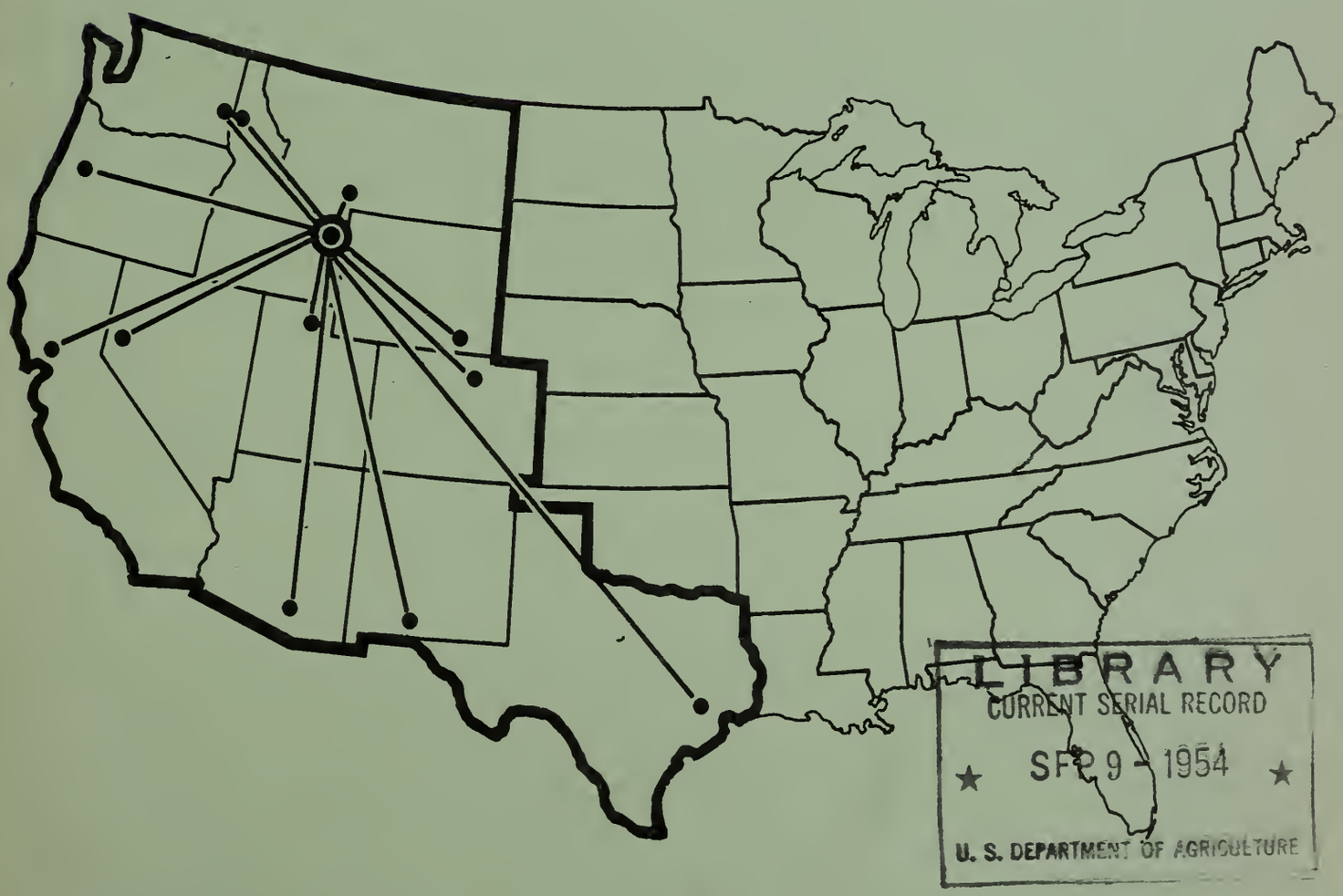
UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH ADMINISTRATION
BUREAU OF ANIMAL INDUSTRY
AND COOPERATING STATES

FIFTEENTH ANNUAL REPORT OF THE

U. S. SHEEP EXPERIMENT STATION and the WESTERN SHEEP BREEDING LABORATORY

DUBOIS, IDAHO

DECEMBER 31, 1952



THIS REPORT OF RESEARCH PROJECTS NOT YET COMPLETED IS INTENDED FOR THE USE OF ADMINISTRATIVE LEADERS AND WORKERS IN THIS OR RELATED FIELDS OF RESEARCH, AND NOT FOR GENERAL DISTRIBUTION.

SUMMARY

Comparisons of different systems of breeding and the development of more effective methods of selection are emphasized in investigations at this Station and Laboratory. Inbred lines of Rambouillet, Targhee and Columbia sheep have been under formation since 1938-40. These lines were started by grouping related animals or by inbreeding to an outstanding ram. Within-line selection for over-all merit has been followed rather uniformly in all lines. This practice is now being changed toward more diversified ways of developing lines. Comparisons are being made between formation of inbred lines by within-line selection and by recurrent selection of sires from line-cross and top-cross progeny tests. Varying rates of inbreeding, selection for single traits and alternative outcrossing and inbreeding are now being contemplated for some of the lines. Testing of lines by crossing is proceeding as rapidly as ewe numbers will permit. Non-inbred selected groups are being developed in each breed for comparisons with inbred lines and their crosses. In addition, a genetically stabilized group of Rambouillets is being established with selection at random to serve as a control for the selected groups. The poorest inbred lines are being culled to make room for these selected and control groups.

Results from analysis of selection gains at this Station and results from theoretical studies are being combined to provide a basis for recommending improved selection procedures. Procedures such as the rapid turnover of generations and the use of selection indexes appear to increase the gains from selection. Analyses of the various traits of lamb and wool production for heritability, economic importance and inter-relationships are being continued. These analyses will provide information used in improving the accuracy and effectiveness of selection methods.

Studies on physiology of reproduction give promise of providing a basis for more effective selection for high fertility at an early age. Special wool studies are concentrated on estimation of economic importance of various wool traits through their relationships to sorting and processing results. Some work on scourable branding fluids shows that they have useful durability, but these studies are being continued. Cooperative sheep grazing studies with the Forest Service are yielding useful information on the prediction of opening date of grazing and grazing capacity from weather records.

ANNUAL REPORT
of the
U. S. Sheep Experiment Station and Western Sheep Breeding Laboratory
Dubois, Idaho
December 31, 1952

Table of Contents

DIRECTORS OF STATE AGRICULTURAL EXPERIMENT STATIONS
OF THE TWELVE WESTERN STATES THAT ARE COLLABORATING
WITH THE WESTERN SHEEP BREEDING LABORATORY
December 31, 1952

ARIZONA:	Phil S. Eckert, University of Arizona, Tucson.
CALIFORNIA:	P. F. Sharp, University of California, Berkeley.
COLORADO:	S. S. Wheeler, Colorado State Agricultural College Fort Collins.
IDAHO:	Donald R. Theophilus, University of Idaho, Moscow.
MONTANA:	M. H. Bell, Acting Director, Montana State College, Bozeman.
NEVADA:	C. B. Hutchison, Nevada Agricultural Experiment Station, University of Nevada, Reno.
NEW MEXICO:	R. A. Nichols, Director, New Mexico State College of Agriculture, State College.
OREGON:	F. E. Price, Oregon State College, Corvallis.
TEXAS:	R. D. Lewis, Agricultural and Mechanical College of Texas, College Station.
UTAH:	D. A. Broadbent, Acting Director, Utah State Agricultural College, Logan.
WASHINGTON:	Mark T. Buchanan, Washington State College, Pullman.
WYOMING:	H. M. Briggs, University of Wyoming, Laramie.

COLLABORATORS OF THE WESTERN SHEEP BREEDING LABORATORY

ARIZONA: Ernest B. Stanley, Head, Department of Animal Husbandry, College of Agriculture, University of Arizona, Tucson.

CALFIORNIA: James F. Wilson, Division of Animal Industry, College of Agriculture, University of California, Davis.

COLORADO: A. Lamar Esplin, Department of Animal Husbandry, Colorado State College of Agriculture and Mechanic Arts, Fort Collins.

IDAHO: Carl F. Sierk, Head, Department of Animal Husbandry, College of Agriculture, University of Idaho, Moscow.

MONTANA: J. L. Van Horn, Department of Animal Husbandry, Montana State College, Bozeman.

NEVADA: Charles E. Fleming, Associate Director, Nevada Agricultural Experiment Station, University of Nevada, Reno.

NEW MEXICO: Philip E. Neale, Department of Animal Husbandry, New Mexico College of Agriculture and Mechanic Arts, State College.

OREGON: F. F. McKenzie, Chairman, Department of Animal Husbandry, Oregon State Agricultural College, Corvallis.

TEXAS: Bruce L. Warwick, Department of Animal Industry, Texas Agricultural Experiment Station, Bluebonnet Farm, McGregor, Texas.

UTAH: James A. Bennett, Department of Animal Husbandry, Utah State College, Logan.

WASHINGTON: M. E. Ensminger, Head, Department of Animal Husbandry, State College of Washington, Pullman.

WYOMING: M. P. Botkin, Department of Animal Production, College of Agriculture, University of Wyoming, Laramie.

ROSTER OF PERSONNEL

U. S. SHEEP EXPERIMENT STATION AND THE WESTERN SHEEP BREEDING LABORATORY
Dubois, Idaho
December 31, 1952

Name	Rating	Date Entered on Duty	General Duties
Nordby, Julius E.	Animal Husbandman	Mar. 1, 1938	Director
Terrill, Dr. Clair E.	Animal Husbandman	July 3, 1936	Genetics and Physiology
Stoehr, John A.	Animal Husbandman	Aug. 28, 1928	Operations
Kyle, Dr. Wendell H.	Animal Geneticist	July 7, 1949	Genetics and Statistics
Wiggins, Dr. Earl L.	Animal Geneticist	Oct. 2, 1950	Genetics and Physiology
Wilson, Lowell O.	Wool Technologist	July 1, 1943	Wool Technologist
Frederiksen, Kenneth R.	Asst. An. Husb. Jr.	July 1, 1951	Idaho Fiscal Agent Operations & Wool
Schaefer, Chester F.	Clerk	June 22, 1936	Chief Clerk
Dunn, Harry A.	Clerk	Aug. 22, 1949	Clerk
Ellis, Lulu F.	Statistical Clerk	Feb. 25, 1952	Clerk
Hensley, Gladys L.	Statistical Clerk	Aug. 4, 1947	Clerk
Maloney, Helen D.	Clerk	Feb. 26, 1951	Clerk
Stoehr, Jessie S.	Statistical Clerk	Aug. 25, 1947	Clerk
Jeffery, Lee C.	Foreman of Farm Laborers	June 7, 1924	General Maintenance Pumps, Equipment
Rasmussen, Jr., Henry	Farm Laborer	July 1, 1926	Sub-Foreman
Anderson, Daniel	Farm Laborer	Aug. 4, 1947	Shepherd
Bybee, Bert L.	Farm Laborer	April 4, 1949	Farm Laborer
Gates, Kendrick J.	Farm Laborer	Nov. 29, 1948	Shepherd
Hohman, Max E.	Farm Laborer	April 1, 1935	Shepherd
Howard, John H.	Farm Laborer	Oct. 2, 1944	Camp Tender
Inbram, Parley F.	Farm Laborer	Apr. 20, 1947	Shepherd
Phillips, Walter H.	Farm Laborer	Mar. 16, 1935	Truck Driver
Powell, Fred A.	Farm Laborer	May 11, 1935	Teamster
Swink, Albert B.	Farm Laborer	May 31, 1946	Farm Laborer
Dunn, Mrs. Helen	Laborer	Oct. 1, 1951	Janitress & Cook

OBJECTIVE

Improvement of sheep through breeding is the general objective of this Station and Laboratory. Investigations of systems of breeding and selection are emphasized. Efforts are concentrated on economically important traits of lamb and wool production under range conditions. Analyses of genetic and environmental attributes of the important traits and their inter-relationships are used as basic guides to the development of more effective methods of breeding and selection.

RESEARCH LINE PROJECTS

BAI-b-2-1-17 Investigation of systems of breeding for improvement of range sheep.

Object: To investigate and compare systems of breeding for the improvement of white face range sheep of finewool and crossbred types for efficient and profitable lamb and wool production on the western ranges.

General plan: Inbred lines of Columbia, Targhee and Rambouillet sheep will be developed in various ways and will be tested in crosses.

Non-inbred strains will be developed by selection.

Groups with artificial selection entirely at random will be developed as controls to inbred lines, their crosses and selected groups.

BAI-b-2-1-18 Investigations of traits for use in breeding and selection of range sheep.

Object: To investigate various attributes of traits in sheep to determine the relative importance of these traits in sheep breeding and selection programs and to obtain essential information for the development of efficient breeding and selection procedures for improvement of these traits.

General plan: All traits on which data are collected will be included. New traits that have promise of usefulness will be added.

Information to be obtained for each trait include the following:

(1) Development and improvement of techniques of measurement.
(2) Determination of mean and variability.
(3) Determination of effects of measurable environmental factors.
(4) Estimation of economic importance.
(5) Estimation of heritability, type of gene action and other genetic attributes.
(6) Calculation of repeatability.
(7) Calculation of genetic and phenotypic relationships to other traits.

This information will be used in development of breeding and selection procedures including the calculation of selection indexes.

BAI-b-2-1-19 Studies in physiology of reproduction of range sheep.

Object: To study attributes of normal reproduction in range sheep and factors which affect it. Emphasis will be placed on the identification of environmental factors which have important effects on reproductive performance and on the development of early measures of potential reproductive performance in both sexes to aid in the selection of highly fertile animals.

General plan: Semen studies will be made on rams before breeding. Studies will be made of sexual development of ram lambs and its relation to subsequent semen production and breeding performance. Age of puberty in ewe lambs will be studied in relation to later production. Animals with abnormalities of reproduction or reproductive organs will be examined. Investigations will be made of factors affecting reproduction of rams and ewes.

BAI-b-2-3-1 Studies of sheep grazing management on spring-fall ranges of the intermountain region in cooperation with the Forest Service.

Object: To determine what method of grazing management with sheep will permit the fullest use of spring-fall range and, at the same time, obtain highest possible forage production.

General plan: These studies will include research on the effect of climate on forage production, the rotation of grazing use of certain ranges, the intensity of grazing use, ways of removing sagebrush and improving spring-fall range by reseeding.

BAI-b-2-3-4 (rev.) Development of improved sheep branding fluids.

Object: To develop a sheep branding fluid that will remain legible and also scour out of the wool by current mill scouring processes.

General plan: Tests will be made of the durability and scourability of various sheep branding fluids.

BAI-b-2-3-5 The response of Targhee sheep to the environment prevailing at the Idaho Agricultural Experiment Station, Moscow, Idaho in cooperation with that Station.

Object: 1. To study the influence of environment in heavy feed-producing areas on wool and lamb production with Targhee sheep.

2. To study the individual rate and efficiency of gains on Targhee sheep.

3. To develop a flock of Targhee sheep with major emphasis on production merit.

General plan: Targhee sheep will be transferred from Dubois to Moscow, Idaho. Records will be taken on these sheep similar to those taken at Dubois. In addition, records of individual rate and efficiency of gain will be made on selected sheep.

BAI-b-2-6-12-c Genetic and physiological factors influencing processing qualities of wool in cooperation with the Wool Division, P.M.A.

Object: - 1. To determine sorting and processing qualities of Columbia, Targhee and Rambouillet wool produced at Dubois, Idaho

2. To obtain information on the usefulness of data on sorting and processing qualities of wool in a breeding and selection program for sheep.

3. To determine the minimum amount and kind of sorting required for satisfactory processing results.

General plan: Fleeces and groups of fleeces sorted according to commercial practices will be studied with respect to wool characteristics in the sorted classes. Processing and manufacturing studies will be carried on with these wools at Beltsville, Maryland, and where feasible in cooperation with other agencies. Data on sorting and processing qualities will be analysed to determine their usefulness in a breeding and selection program. Processing studies will be carried on with lots of wool from sorted, partially sorted and unsorted fleeces.

PUBLICATIONS

The following papers have been prepared for publication since June 30, 1951. A complete list of publications was presented in the fourteenth annual report of the U. S. Sheep Experiment Station and Western Sheep Breeding Laboratory. Reprints of many of these publications are available. Some publications of other agencies are included of work to which the Station and Laboratory have contributed. A number of articles have appeared in livestock journals and the general press that are not included in this series. They are generally adaptations of the regular series but rewritten for the lay reader.

97. Relationships Between Libido, Semen Characteristics and Fertility in Range Rams. (Includes data from 1946-1949). Earl L. Wiggins, Clair E. Terrill and L. Otis Emik. Proc. West. Sec. Amer. Soc. An. Prod. 2:57, July 9, 10, 1951.

98. The Relative Accuracy of Individual and Committee Average Scores for Evaluating Weanling Lamb Traits. Wendell H. Kyle. Proc. West. Sec. Amer. Soc. An. Prod. 2:161, July 9, 10, 1951.

99. Heritabilities and the Relative Accuracies of Individual and Committee Scores for Some Traits of Sheep. W. H. Kyle. For Journal of Animal Science.

100. Optimum Selection and Mating Procedures for Intra-flock Improvement of Sheep. W. H. Kyle. Proc. West. Sect. Amer. Soc. An. Prod. 3:XIV, 1-5, June 23, 24, 1952.

101. The Relation Between Sale Price and Merit in Columbia, Targhee and Rambouillet Rams. Clair E. Terrill. Proc. West. Sect. Am. Soc. An. Prod. 3:XX, 1-10, June 23, 24, 1952.

102. Relationships Between Libido, Semen Characteristics and Fertility in Range Rams. (Includes data from 1936-1950). E. L. Wiggins, C. E. Terrill and L. O. Emik. Proc. West. Sect. Am. Soc. An. Proc. 3:XXIII, 1-10, June 23, 24, 1952.

103. Reconciling Natural and Artificial Selection in Range Sheep Improvement. Julius E. Nordby. Montana Wool Grower 26(9):25, 27, 30, 32, Sept., 1952.

104. Effect of Several Chemicals on Tall Larkspur and Associated Tailcup Lupine. Walter F. Mueggler. Intermountain Forest and Range Experiment Station Research Note No. 4, June, 1952.

105. Variations in Chemical Composition of Bluebunch Wheatgrass, Arrowleaf Balsam Root and Associated Range Plants. James P. Blaisdell, A. G. Wiese and C. W. Hodgson. Jour. Range Management 5(5):346-353, Sept., 1952.

106. Development of the Penis in Ram Lambs. Earl L. Wiggins and Clair E. Terrill. For Journal of Animal Science.

107. Experimental Check of the Effectiveness of Selection for a Quantitative Character. W. H. Kyle and A. B. Chapman. To Appear in Genetics.

108. Predicting Live Normal Sperm in Rams from Motility Scores. L. Otis Emik, Clair E. Terrill and George M. Sidwell. For Journal of Animal Science.

109. Phenotypic and Genetic Correlations Between the Weanling Traits of Range Rambouillet Lambs. L. N. Hazel and Clair E. Terrill. For Journal of Animal Science.

110. Construction and Use of a Selection Index for Range Rambouillet Lambs. Clair E. Terrill and L. N. Hazel. For Journal of Animal Science.

111. The Effect of Selection on the Incidence and Heritability of Neck Folds in Rambouillet Weanling Lambs. Clair E. Terrill and W. H. Kyle. For Journal of Animal Science.

ABSTRACTS

The following abstracts have been published by the U. S. Sheep Experiment Station and The Western Sheep Breeding Laboratory since June 30, 1951. In general these are abstracts of work that has been or will be published in the regular series of publications. A complete list of abstracts appeared in the fourteenth annual report.

26. Heritabilities and the Relative Accuracies of Individual and Committee Scores for Some Traits of Sheep. W. H. Kyle. Jour. An. Sci. 10(4):1027, Nov., 1951.

27. The Effect of Selection on the Incidence and Heritability of Neck Folds in Rambouillet Weanling Lambs. Clair E. Terrill and W. H. Kyle. Jour. An. Sci. 11(4):744-745, Nov., 1952.

28. Development of the Penis in Ram Lambs. Earl L. Wiggins and Clair E. Terrill. Jour. An. Sci. 11(4):804, Nov., 1952.

BREEDING PLANS 1951-52

A total of 2522 ewes were bred in 1951. Rambouillet pen-breeding extended from November 2 to December 3 and range breeding from December 10 to January 5. Range breeding involved turning Columbia rams in with the Rambouillet ewes (about a week after the ewes came out of pen breeding) to settle ewes that did not conceive to pen breeding. Offspring were tagged in the "T_1" series. Columbia and Targhee ewes were pen-bred from November 20 to December 20. The distribution of ewes by breed and type of mating is shown in the following table:

Breed	No. of ewes bred	Inbred lines		Breed crosses		Line crosses		Selected controls		Test ewes		Black* markers	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Rambouillet	1264	740	59			223	18	197	15	93	7	11	1
Targhee	714	480	67	13	2			35	5	175	24	11	2
Columbia	544	331	61			146	27	67	12				
ALL	2522	1551	61	13	1	369	15	299	12	268	10	22	1

* Black marker ewes were not used in the breeding program.

Rambouillet lines

There are 29 inbred lines of Rambouillets. The average number of ewes per line was 25.5 as compared with 27.9 in 1950. There are 8 lines of registered Rambouillets and 5 lines of polled Rambouillets. Ram 7491DLF, which was used to introduce the polled gene in line 32, appears to be homozyonous for the polled gene. He was used again in line 32, which now contains 29 of his daughters, to determine whether he carries a recessive gene for cryptorchidism. The 6 ram lambs weaned out of daughters of 7491DLF were all free of cryptorchidism. This result would be expected about 45% of the time due to chance even if the sire carried the recessive gene for cryptorchidism.

Rambouillet cross lines

The plan for crossing Rambouillet lines had to be changed this year since a marked reduction in numbers of ewes occurred in some of the lines due to their previous use for crossing. No ewes were taken from line 22 this year and only half as many ewes were taken from lines 40 and 45 as last year. Again 20 ewes were used from each of lines 49, 50 and 51. Ten instead of 12 ewes were taken from lines 25 and 44 for reciprocal crosses. Two sires each from lines 21, 23, 25, 43 and 44 were mated to 1 ewe each from lines 40 and 45 and 2 ewes each from lines 49, 50 and 51. One sire each from lines 40, 45, 49, 50 and 51 was mated to 2 ewes each from lines 25 and 44. In each of

the lines involved in crossing the ewes remaining in the line were divided at random to 2 sires from that line. There were 41 2-year-old, 2-line-cross ewes available this year from line crossing started in 1949. These were sorted at random (except that back crosses were avoided) to lines 21, 23, 25, 43 and 44 to obtain additional information on the crossing ability of these lines. Information obtained from the 3 years of crossing completed this year provides a basis for selecting lines on crossing ability.

Rambouillet selected control group

This group of about 200 ewes which was initiated in 1947 is maintained with as little inbreeding as possible with emphasis on selection for traits of high heritability and high economic importance. This year six rams were mated to 197 ewes. Two of the rams were proven by progeny test last year and were mated to about 40 ewes each. The other 4 rams including 3 yearlings and one ram lamb were selected on their own merit and were mated to about 30 ewes each.

Rambouillet recurrent selection

Two pairs of 2 lines each (20, 27 and 53, 54) are being developed by selecting sires on crossing ability with the other line. Four sires from each line are mated with 5 ewes each from the other line. The best sire on the basis of his crossing ability with the other line is used back in his own line the following year. Indexes have been developed for preliminary selection at weaning age, at yearling age and for comparing progenies. The cross line information obtained can be compared with the other line crosses in Rambouillets. Also the cross line information is supplemented with top cross data by mating about 5 test ewes with each line sire being tested.

Rambouillet test matings

Test matings in addition to those used from cross-lines and recurrent selection were confined to testing rams from line 28 for recessive black. Ram 9115W produced black lambs when mated to daughters and his son also produced black lambs when mated to half sisters. Of the 5 sires used in the line it appears that 9115W and his son were the only sires carrying the black gene. Only sons of 9115W are available now and 2 of these were each mated to half of the ewes from line 28 this year. In addition each was mated to 6 daughters of a sire borrowed from the Utah Station who is known to have sired a black lamb. No black offspring were produced so it is planned to cull all mature female descendants of 9115W and to maintain the line with the remaining ewes and the tested ram. If this procedure is not successful it may be desirable to cull the line rather than attempt to eliminate the black gene by selection and inbreeding.

Targhee lines

A total of 480 ewes were mated in 18 inbred lines. The average number of ewes per line was 26.7 which is about the same as last year. eight of these lines (1T to 8T) were initiated in 1940. Line 9T was

started from Columbia-Rambouillet crosses which were first made in 1943. Line 10T originated from crosses of a Border Leicester ram on Targhee and Rambouillet ewes. The descendants have been backcrossed to Rambouillet rams so that only those with Targhee type (half-blood) fleeces are interbred in line 10T. Lines 11T to 14T were initiated from Rambouillet lines crossed with Corriedale lines. The first crosses were started in 1945. Line 15T resulted from crosses of New Zealand Merino rams on Columbia, Targhee and Rambouillet ewes. The first crosses were made in 1945. Lines 16T to 18T were split at random in 1950 from lines 4T, 9T and 15T, respectively, in order to provide a comparison between lines formed by recurrent selection on crossing ability and those formed by intra-line selection on own merit.

Targhee selected control group

This group is being started this year by randomizing 2 test ewes to each of the 18 lines. Offspring from these and future matings will be the foundation for a selected control group in which selection will be emphasized and inbreeding will be minimized.

Targhee recurrent selection

Three Targhee lines (16T to 18T) are being developed by recurrent selection. Six yearling rams from each line are tested each year by top crossing with about 10 test ewes per ram. After the first generation, the test ewe offspring will be rotated so that rams from each line will be mated to ewes which are sired by rams from another line. Eventually the sires will be tested on ewes containing about 57% of the second line, 29% of the third line and 14% of their own line. The ram with the best test progeny will be mated to the ewes of his own line the following year. Crosses among lines 16T to 18T can be compared later with crosses among the parent lines 4T, 9T and 15T. These latter three lines are being continued by inbreeding and selecting within the lines.

Targhee test matings

All Targhee test ewes are used for recurrent selection and for initiating the selected control group.

Columbia lines

There are 10 inbred lines of Columbias. The average number of ewes per line was 33.1 as compared with 35.5 in 1950.

Columbia cross lines

Cross-line matings were made with 7 of the 10 Columbia lines this year. Each of two sires from each of these lines was mated with 10 or 11 cross-line ewes. These ewes were made up of crosses of 2 to 4 lines made in previous years. In most cases the sire was not mated to crossline ewes descended from his own line. The 3 lines not used in crossing this year are 1, 5 and 7 which have been crossed considerably in previous years.

Columbia selected control group

This group was started this year by randomizing all of the Columbia test ewes (67 head) among the 10 lines. The Columbia test ewes were of the LR, K1L, K1B, K2 and K series. Rams of the K series when mated to these ewes produced K1L, K2, K2, K and K series offspring, respectively. It is planned to use only K series offspring to be intermated in the control group. Ewes and ewe offspring of the other series will continue to be randomized through the lines.

Recapitulation

About 61 percent of the flock was devoted to the development of inbred lines and 15 percent was used to test the crossing ability of these lines. Approximately 12 percent of the flock was used as selected controls. The remaining 12 percent was used for progeny testing.

PROGRESS IN DEVELOPING INBRED LINES

Rambouillets

The following table shows the change in inbreeding since 1938. These data are based on ewes bred.

Year lambed	No. of lines	No. of ewes bred	Average Inbreeding Coefficients in Percent: Sires	Dams	Progeny	Increase of progeny over dams	Highest for progeny of any pen	Highest for any individual offspring
1938	20	500	4.0	1.1	3.9	2.8	13.3	37.9
1939	22	560	7.5	3.2	7.2	4.0	30.3	58.3
1940	34	805	6.0	3.6	8.2	4.6	32.6	58.3
1941	36	850	3.3	2.7	8.6	5.9	31.2	47.3
1942	37	1023	4.1	4.0	8.6	4.6	28.7	39.9
1943	30	903	4.4	4.2	8.9	4.7	23.0	36.9
1944	30	908	5.0	5.0	10.3	5.3	22.8	48.0
1945	30	962	6.0	5.8	14.2	8.4	26.8	42.5
1946	30	890	5.9	7.1	14.1	7.0	25.7	39.4
1947	30	897	8.6	8.1	15.6	7.5	29.0	55.2
1948	29	882	14.6	9.7	17.1	7.4	30.5	42.9
1949	29	1002	13.4	11.9	15.8	3.9	32.6	44.2
1950	29	851	13.6	13.6	16.8	3.2	32.4	46.0
1951	29	808	15.3	13.6	19.4	5.8	37.1	50.5
1952	29	740	15.1	13.9	20.6	6.7	39.1	50.5

The average inbreeding coefficients were as high or higher in 1951 and 1952 than in previous years for sires, dams and offspring. The average increase in inbreeding of offspring since 1938 is slightly greater than 1 percent per year.

The average inbreeding coefficients of all lambs weaned in Rambouillet inbred lines was 18.41 and 20.10 percent, respectively, for 1951 and 1952. The average inbreeding coefficient of lambs saved in 1951 was 19.07 for ram lambs as compared with 18.88 for all ram lambs and it was 17.80 for ewe lambs as compared with 17.98 for all ewe lambs.

The six highest ranking lines for each of the important traits measured at weanling age are listed in the next table for comparison with similar tables presented in previous years. These lines were ranked on adjusted averages from weanling offspring in 1951. Weighted averages of offspring from 2 sires from the same line were used.

Rank of Rambouillet Lines in 1951

Trait	1st	2nd	3rd	4th	5th	6th
Body weight	32	34	24	27	22	46
Body type	24	25	32	34	22	27
Condition	24	22	32	25	40	34
Staple length	53	26	34	47	37	39
Open face	40	36	49	22	27	25
Freedom from folds	32	37	42	45	44	23
Index	40	32	36	27	22	34

Nineteen of the 29 lines are included in the table of which 12 were included last year. Three lines (40, 44 and 47) have ranked in the high six for one or more traits for each of the last 11 years, but not necessarily for the same trait each year. Line 34 has also ranked in the high six for each of the last 11 years except for one year from which it was excluded because of an outcross.

The ranks of the six highest lines for weanling offspring in 1952 are presented in the following table:

Rank of Rambouillet Lines in 1952

Trait	1st	2nd	3rd	4th	5th	6th
Body weight	26	24	32	35	27	40
Body type	27	24	29	22	34	26
Condition	26	24	27	22	34	32
Staple length	29	39	45	47	50	25
Open face	40	36	51	44	27	32
Freedom from folds	20	47	23	50	44	45
Index	40	36	32	44	27	50

Nineteen of the 29 lines are included in the table of which 14 were included last year. Three lines (40, 44 and 47) have ranked in the high six for one or more traits for each of the last 12 years. Also line 34 has ranked the high six for each of the last 12 years except for one year from which it was excluded because of an outcross.

Targhees

The Targhee lines which were established in 1940 and later years have been continued by using one ram in each line. The progress of inbreeding in these lines is shown in the next table. These data are based on ewes bred.

Year lambed	No. of lines	No. of ewes bred	Average inbreeding coefficients in percent: Sires	Dams	Progeny	Increase of progeny over dams	Highest for progeny of any pen	Highest for any individual offspring
1941	8	192	8.2	3.5	9.6	6.1	16.4	30.9
1942	8	183	8.5	3.5	10.6	7.1	17.4	34.9
1943	8	202	7.2	3.5	10.6	7.1	22.5	34.9
1944	8	223	8.7	4.6	11.2	6.6	16.0	31.0
1945	8	257	5.0	7.5	13.1	5.6	20.8	35.9
1946	8	245	3.4	7.2	11.5	4.3	18.9	36.2
1947	9	299	4.9	7.2	12.3	5.1	21.9	41.4
1948	13	318	8.1	6.0	13.9	7.9	19.8	44.7
1949	14	409	8.9	5.9	13.0	7.1	23.4	35.2
1950	14	420	7.7	6.1	13.2	7.1	25.5	34.9
1951	17	455	10.1	6.6	14.4	7.8	25.7	40.1
1952	17	466	10.6	7.9	15.0	7.1	28.8	44.1

The average inbreeding coefficients increased in 1951 and 1952 as was expected. The slow increase in inbreeding since 1941 is believed due to the introduction of new stock in the forming of additional lines. Line 10T is still not included in the table as inbreeding coefficients have not been calculated for it yet.

The average inbreeding coefficient for all lambs weaned in Targhee inbred lines was 13.50 and 12.44 percent, respectively, for 1951 and 1952. The average inbreeding coefficients of lambs saved in 1951 was 12.92 for ram lambs as compared with 13.42 for all ram lambs and it was 13.32 for ewe lambs as compared with 13.57 for all ewe lambs.

The four highest ranking lines (of 17 lines in 1951 and 18 lines in 1952) for each of the more important traits measured at weanling age are listed in the next tables. These lines were ranked on adjusted averages from weanling offspring in 1951 and 1952.

Rank of Targhee lines in 1951

Trait	1st	2nd	3rd	4th
Body weight	1T	7T	3T	12T
Body type	7T	5T	12T	4T
Condition	9T	3T	12T	7T
Staple length	18T	5T	2T	1T
Open face	17T	12T	14T	2T
Freedom from folds	4T	1T	14T	13T
Index	1T	17T	12T	14T

Rank of Targhee lines in 1952

Trait	1st	2nd	3rd	4th
Body weight	1T	17T	10T	12T
Body type	7T	1T	3T	10T
Condition	10T	12T	1T	3T
Staple length	8T	1T	6T	5T
Open face	10T	12T	16T	15T
Freedom from folds	8T	14T	1T	5T
Index	8T	10T	12T	1T

Twelve of 17 lines were included in the table in 1951 and 12 of 18 lines were included in 1952. Three lines (1T, 3T and 7T) have been included in the high 4 lines for 1 or more traits in each of the last 3 years.

Columbias

The next table shows the average inbreeding in Columbia lines in 1951 and 1952. These data are based on ewes bred. Summaries for previous years are nearing completion.

Year lambed	No. of lines	No. of ewes bred	Average inbreeding coefficients in percent: Sires	Dams	Progeny	Increase of progeny over dams	Highest for progeny of any pen	Highest for any individual offspring
1951	10	355	12.6	12.4	17.4	5.0	23.3	34.0
1952	10	331	14.6	13.9	17.9	4.0	24.1	35.6

The average inbreeding coefficient of all lambs weaned in Columbia inbred lines was 16.33 and 16.87 percent, respectively, for 1951 and 1952. The average inbreeding coefficients of lambs saved in 1951 was 15.23 for ram lambs as compared with 16.13 for all ram lambs and it was 16.47 for ewe lambs as compared with 16.55 for all ewe lambs.

The 4 highest ranking lines (of 10 lines) for each of the more important traits measured at weanling age are listed in the next tables. These lines were ranked on adjusted averages from weanling offspring in 1951 and 1952.

Rank of Columbia lines in 1951

Trait	1st	2nd	3rd	4th
Body weight	7	3	9	10
Body type	9	2	3	7
Condition	9	3	10	8
Staple length	1	2	3	8
Fineness code	5	10	6	4
Index	1	7	3	2

Rank of Columbia lines in 1952

Trait	1st	2nd	3rd	4th
Body weight	3	9	1	10
Body type	1	6	3	10
Condition	6	1	8	9
Staple length	4	2	6	1
Fineness code	5	3	8	6
Index	2	6	3	7

All of the 10 lines were included in the table both in 1951 and in 1952. Eight lines (all but 8 and 10) have been included in the high 4 lines for 1 or more traits in each of the last 3 years.

RECURRENT SELECTION

Recurrent selection refers to the development of lines by selecting individuals for crossing or combining ability with other lines or with a tester stock. Preliminary work was started in the fall of 1950 with 2 pairs of lines of Rambouillets and with 3 lines of Targhees. Indexes have been developed for the initial selection of rams to be tested and for the selection of the ram to be used in the line on the basis of the progeny test results.

Initial selections of rams to be tested are based on traits in which the genetic portion of the variance is largely additive in nature. Indexes have been developed for use with Rambouillets and Targhees which are based on these traits alone. The index at weanling age equals 10 plus staple length in centimeters minus 1.2 times face covering score minus 0.3 times neck folds score. The index developed for use at yearling age equals 50 plus 4 times clean fleece weight in pounds plus staple length in centimeters minus 7 times face covering score minus 2 times neck folds score.

$$(Ix = 50 + 4\,Cl + L - 7F - 2N)$$

Clean fleece weight was included although its genetic variation is not largely additive, because of the difficulty of selecting for it with a progeny test based on weanling traits. Selection of the 4 or 6 rams to be tested are made using these indexes. Rams with serious defects not covered by the index are culled at weaning age.

Another index was developed to select the ram to be used in the recurrent selection line on the basis of the progeny test results. This index emphasizes traits in which a significant portion of the genetic variance is non-additive in nature. The relative measure used for the non-additive portion of the genetic variance was the square of the regression per 10 percent of inbreeding divided by the total variance. The index obtained equals average weaning weight of progeny in pounds minus 1.8 times average type score minus 1.15 times average condition score.

$$(Ix = W - 1.8T - 1.15C)$$

This index is considered to be only a rough approximation which will be revised as soon as information on genetic sources of variation in each trait can be obtained and accurate methods worked out for use in recurrent selection. It is possible that a better index would result if the relative proportions of total genetic variance in the traits were used.

Rambouillets

Averages from sires tested for recurrent selection are presented in the next table. Averages have been adjusted for environmental effects including inbreeding except that the inbreeding (due to inter-line and intra-flock relationships) is unknown for cross-line and top-cross offspring. Sires used in the lines for 1951 offspring were not selected from progeny tests but those used for 1952 offspring were selected on this basis. Rams born from tested sires will be tested first in 1953.

Averages from Rambouillet lines, line-crosses and top-crosses in recurrent selection*

Trait	Year	Line 20	Line-crosses 27x20	Line-crosses 20x27	Line 27	Top-crosses 20	Top-crosses 27
Number of offspring	51	22	17	24	27	18	25
	52	6	11	13	22	14	13
Weaning weight (lbs.)	51	76.0	77.2	76.7	84.4	79.1	81.2
	52	74.8	70.6	68.5	80.8	72.7	80.1
Type score	51	2.17	1.95	2.06	1.76	2.05	1.93
	52	2.31	2.49	2.50	1.94	2.37	2.25
Condition score	51	2.83	2.56	2.65	2.53	2.54	2.50
	52	2.52	2.71	2.73	2.15	2.37	2.52
Index	51	68.9	70.7	70.0	78.4	72.5	74.8
	52	67.8	63.0	60.8	74.9	65.7	73.1

Trait	Year	Line 53	Line-crosses 54x53	Line-crosses 53x54	Line 54	Top-crosses 53	Top-crosses 54
Number of offspring	51	16	25	25	26	19	17
	52	17	19	7	21	13	14
Weaning weight (lbs.)	51	78.2	75.3	75.6	77.7	79.5	81.1
	52	74.8	71.5	73.8	71.6	79.0	81.1
Type score	51	1.82	2.01	1.93	1.80	1.80	1.75
	52	2.20	2.38	2.30	2.42	2.15	2.20
Condition score	51	2.74	2.73	2.61	2.55	2.62	2.52
	52	2.58	2.67	2.54	2.85	2.43	2.18
Index	51	71.8	68.6	69.2	71.5	73.2	75.0
	52	67.8	64.1	66.8	64.0	72.3	74.7

* The larger type and condition scores represent poorer merit. The index shown is that used for selection on progeny test results.

Averages for cross-line progenies of lines 20 and 27 were generally intermediate to the parent lines in 1951 and poorer than the parent lines in 1952. The situation was reversed with lines 53 and 54 in that the cross-line offspring were poorer than those from the parent lines in 1951 and were intermediate in 1952. Likewise 20 and 27 cross progeny excelled those from 53 and 54 in 1951 but not in 1952. Line 27 had the best straight line progeny in both years but line 54 had the best top-cross

progeny in both years followed in order by lines 27, 53 and 20. Top-cross offspring generally excelled cross-line offspring. This may have been due to the greater productivity of the non-inbred mothers. The failure of the cross-line offspring to excell the straight line offspring in all but a few cases may indicate that the initial combining ability of these lines is low. Adjustments of straight-line data for inbreeding may be misleading in comparing cross-lines with straight lines as they are based on estimates of the effect of inbreeding in former years which may be too high. Furthermore the inbreeding in the cross-line offspring due to relationship between lines is unknown but may be large enough to affect the results. These possibilities will be investigated before analysis of these data is completed.

Selection differentials based on progeny averages for rams selected for use in recurrent selection lines are shown in the next table. It is apparent that results from cross-line progeny are not always consistent with those from top-cross progeny. An efficient method for combining line-cross and top-cross results is needed.

In 1952 two "third-choice" rams were used because the first two choices were either missing or infertile. It appears best in the future not to use rams that were below the average of all rams tested. It is planned to select untested rams instead. Data are being analysed to determine the relation between the ram's own records and the records of his line-cross and top-cross progeny.

Selection differentials from progeny averages of rams tested for recurrent selection lines*.

Year	Line	Ram used	Rank of crossline progeny	No. of prog. of sel. ram	No. of prog. of all rams	Selection differentials for cross-line results				No. of prog. of sel. ram	No. of prog. of all rams	Selection differentials for top-cross results			
						weight lbs.	type score	cond. score	Index			weight lbs.	Type score	Cond. score	Index
1951	20	2362RW	1	4	24	4.48	.08	-.09	4.52	3	18	-4.01	.02	-.32	-4.34
	27	2822RW	1	4	17	2.95	.46	.11	3.72	7	25	-3.92	-.04	-.06	-4.06
	53	9992W	1	6	25	7.64	.33	.22	8.49	4	19	2.44	-.03	-.11	2.26
	54	9240W	1	7	25	4.72	.22	.26	5.42	5	17	-.11	-.08	-.09	- .36
1952	20	3163RW	1	2	13	3.85	.75	.64	5.95	4	14	1.89	.14	.26	2.46
	27	3072RW	3	5	11	-1.36	-.24	0	-1.76	3	13	-1.05	.20	.03	-.63
	53	1309W	3	2	7	-5.58	-.08	-.23	-5.96	5	7	1.56	-.04	-.24	1.24
	54	991W	1	7	19	3.21	.22	.11	3.76	5	14	1.74	.04	.12	1.97

* A negative selection differential for any trait indicates that the ram's progeny were poorer than the average for that trait.

Targhees

Recurrent selection is being practiced on 3 lines of Targhees (16T, 17T and 18T). Six rams from each line were tested on groups of 8 to 11 ewes each. The results of these tests are shown in the next table. Averages have been adjusted for environmental effects including inbreeding except that the inbreeding is unknown for top-cross offspring. Sires used in the lines for 1951 offspring were not selected from progeny tests but those used for 1952 were selected on this basis.

		Top-crosses			Straight lines		
Trait	Year	16T	17T	18T	16T	17T	18T
Number of offspring	1951	91	79	81	29	33	34
	52	36	47	42	12	20	22
Weaning weight (lbs.)	51	88.9	88.7	88.0	85.2	90.9	86.4
	52	81.8	82.3	84.5	79.5	90.8	82.0
Type score	51	1.84	1.90	1.76	1.87	1.77	1.73
	52	1.75	1.98	1.98	2.04	1.78	1.98
Condition score	51	2.21	2.23	2.20	2.21	2.25	2.24
	52	2.14	2.40	2.19	2.38	2.06	2.24
Index	51	83.1	82.7	82.3	79.3	85.1	80.7
	52	76.2	76.0	78.4	73.1	85.2	75.8

The top-cross progenies of the 3 lines were very similar in 1951. Top-cross progeny of 18T were slightly superior to the other 2 lines in 1952. Straight-line progeny from 17T excelled the other 2 lines for progeny index in both years.

Selection differentials based on progeny averages for rams selected for use in recurrent selection lines are shown in the following table.

Selection differentials from top-cross progeny averages of rams tested for recurrent selection of lines*.

Year	Line	Ram used	Rank of top-cross progeny	No. of prog. of sel. ram	No. of prog. of all rams	Selection differentials for weight lbs.	type score	cond. score	Index
1951	16T	4442T	1	17	91	2.36	-.02	.09	2.42
	17T	4968T	1	11	79	3.31	.04	.15	3.55
	18T	5059T	1	13	81	2.35	.09	-.02	2.46
1952	16T	5460T	2	8	36	2.10	.03	.18	2.38
	17T	5807T	1	10	47	6.21	.22	.21	6.87
	18T	5359T	2	8	42	3.88	.08	-.04	4.01

* A negative selection differential for any trait indicates that the ram's progeny were poorer than the average for that trait.

Selection differentials appear to be fairly low in spite of the fact that the best first or second ram of six was selected. Second choice rams were used in 2 cases in 1952 because one first choice ram was missing and another had poor semen.

LINE CROSSES

Rambouillets

The testing of some Rambouillet lines for combining ability was continued in 1950-51 and 1951-52 with the same plan as in 1949-50.

Some preliminary comparisons of sire lines on results from line-cross lambs born in 1951 and 1952 are given in the next table. These data have been corrected for environmental effects except that data for line-cross offspring have not been corrected for the inbreeding which may exist because of relationship between the lines. Averages for lines have been weighted by the number of offspring from each sire. Averages for offspring of dam lines have been weighted by the number of line-cross offspring from each dam line.

Line 44 gave the best results in crossing. Line-cross offspring sired by line 44 rams were superior to both parent groups in 5 of 8 comparisons and were superior to other line-cross groups in 6 of 8 comparisons. Line 21 appeared to rank next in crossing ability followed in order by lines 25, 23 and 43. Line 43 has already been discarded. Line 25 was one of the best sire lines on its own records and, although its line-cross offspring were intermediate in rank, they were poorer than both parent groups in 6 of 8 comparisons.

Results from Rambouillet lambs born in 1951

Sire line	No. of offspring from Own line	No. of offspring from Line crosses	Ave. weaning weight of offspring from Own line	Ave. weaning weight of offspring from Line crosses	Ave. weaning weight of offspring from Dam lines	Ave. condition scores of offspring from Own line	Ave. condition scores of offspring from Line crosses	Ave. condition scores of offspring from Dam lines
21	24	28	79.6	77.3	80.1	2.65	2.52	2.58
23	31	22	79.2	77.9	80.7	2.51	2.62	2.56
25	16	27	81.6	78.0	79.6	2.41	2.69	2.61
43	8	26	75.7	77.3	79.9	2.81	2.73	2.61
44	26	26	80.9	80.4	79.9	2.58	2.41	2.58

Sire line	No. of offspring from Own line	No. of offspring from Line crosses	Ave. type scores of offspring from Own line	Ave. type scores of offspring from Line crosses	Ave. type scores of offspring from Dam lines	Ave. indexes* of offspring from Own line	Ave. indexes* of offspring from line crosses	Ave. indexes* of offspring from Dam lines
21	24	28	2.21	2.00	1.92	127.2	127.3	138.3
23	31	22	1.83	2.04	1.90	125.8	129.8	138.2
25	16	27	1.71	2.01	1.93	138.3	131.8	137.4
43	8	26	2.11	2.04	1.93	117.9	124.7	137.2
44	26	26	1.90	1.79	1.92	134.6	134.6	137.4

Results from Rambouillet lambs born in 1952

Sire line	No. of offspring from Own line	No. of offspring from Line crosses	Ave. weaning weight of offspring from Own line	Ave. weaning weight of offspring from line crosses	Ave. weaning weight of offspring from Dam lines	Ave. condition scores of offspring from Own line	Ave. condition scores of offspring from Line crosses	Ave. condition scores of offspring from Dam lines
21	4	10	65.2	79.0	77.2	3.08	2.41	2.61
23	15	10	75.1	70.4	77.4	2.70	2.89	2.64
25	11	12	76.7	73.9	76.2	2.59	2.60	2.61
43	6	12	72.7	69.4	77.7	2.59	2.75	2.58
44	15	10	74.8	78.4	78.4	2.81	2.19	2.59

Sire line	No. of offspring from Own line	No. of offspring from Line crosses	Ave. type scores of offspring from Own line	Ave. type scores of offspring from Line crosses	Ave. type scores of offspring from Dam lines	Ave. indexes* of offspring from Own line	Ave. indexes* of offspring from Line crosses	Ave. indexes* of offspring from Dam lines
21	4	10	2.78	2.44	2.28	115.0	129.1	131.6
23	15	10	2.35	2.40	2.28	118.3	118.2	134.3
25	11	12	2.25	2.29	2.27	128.6	134.1	132.3
43	6	12	2.49	2.62	2.27	109.7	117.3	132.5
44	15	10	2.19	2.14	2.26	135.0	126.0	135.4

* All indexes shown in this table are the regular selection indexes which include face covering, neck folds, staple length, weight, type and condition.

Columbias

Line-cross Columbia ewes were randomized among 2 rams each from lines 2, 4, 8, 9 and 10 in 1950-51 and from lines 2, 3, 4, 6, 8, 9 and 10 in 1951-52. Each ram was mated to half of the ewes from his own line in addition to the line-cross ewes. Some preliminary results are presented in the next table. These data have been corrected for environmental effects except that data for line-cross offspring have not been corrected for the inbreeding which may exist because of the relationship between the lines. Averages for lines have been weighted by the number of offspring from each sire.

Line-cross offspring were generally superior to straight-line offspring in overall merit as shown by the index. The only exception was line 4 in 1952. Line 2 produced the best straight-line and line-cross offspring, as shown by the index in both years.

The advantages in index of all line-cross offspring over all inbred offspring were 0.5% in 1951 and 1.8% in 1952. Adjustments for the inbreeding in line-crosses would increase this advantage.

Results from Columbia lambs born in 1951

Sire line	No. of offspring from Own line	No. of offspring from Line crosses	Ave. weaning weight of offspring from Own line	Ave. weaning weight of offspring from Line crosses	Ave. condition score of offspring from Own line	Ave. condition score of offspring from Line crosses
2	41	24	87.9	90.0	2.16	2.13
4	23	31	83.2	87.4	2.23	2.17
8	44	28	87.4	88.9	2.09	2.22
9	18	26	90.4	89.2	1.90	2.12
10	29	26	89.2	91.1	2.06	2.06

Sire line	No. of offspring from Own line	No. of offspring from Line crosses	Ave. type score of offspring from Own line	Ave. type score of offspring from Line crosses	Ave. index* of offspring from Own line	Ave. index* of offspring from Line crosses
2	41	24	1.69	1.79	132.1	135.2
4	23	31	1.94	1.99	127.6	131.8
8	44	28	1.87	1.94	131.4	133.2
9	18	26	1.43	1.85	131.8	132.6
10	29	26	1.80	1.74	130.1	133.0

Results from Columbia lambs born in 1952

Sire line	No. of offspring from Own line	No. of offspring from Line crosses	Ave. weaning weight of offspring from Own line	Ave. weaning weight of offspring from Line crosses	Ave. condition score of offspring from Own line	Ave. condition score of offspring from Line crosses
2	26	8	84.5	85.9	2.19	2.35
3	7	13	85.7	82.1	2.21	2.25
4	12	6	77.0	72.6	2.53	2.71
6	5	4	83.9	87.3	2.05	2.04
8	14	10	79.5	82.0	2.14	2.25
9	12	12	85.6	84.8	2.17	1.88
10	18	14	84.7	82.1	2.25	2.18

Sire line	No. of offspring from Own line	No. of offspring from Line crosses	Ave. type score of offspring from Own line	Ave. type score of offspring from Line crosses	Ave. index* of offspring from Own line	Ave. index* of offspring from Line crosses
2	26	8	1.84	1.57	125.4	130.4
3	7	13	1.70	1.82	124.3	125.1
4	12	6	1.85	2.19	121.1	118.0
6	5	4	1.74	1.60	125.2	129.0
8	14	10	2.02	1.84	117.9	123.4
9	12	12	1.84	2.09	121.9	124.7
10	18	14	1.80	2.08	122.6	125.0

* All indexes shown in this table are the regular selection indexes which include staple length, weight, type, condition and fineness.

SELECTED NON-INBRED CONTROL GROUP

This breeding group of Rambouillets was started in the fall of 1947 to serve as a control group to compare improvement resulting from the utilization of inbred lines with that resulting from selection without inbreeding. In the first two years it was necessary to use sires from outside the group. The majority of lambs born in 1950 and all lambs born in 1951 and 1952 were sired by rams selected from the control group.

Comparisons of the averages of weanling offspring of the control group with those of the inbred lines for 1948 to 1952 are shown in the next table. Adjustments were made for environmental effects and inbreeding except that control groups in 1951 and 1952 were not adjusted for inbreeding. Calculations of inbreeding coefficients for control groups in 1951 and 1952 have not yet been completed.

Group	Year	No. of lambs	Inbr. coef. %	Face covering score	Staple length (cm.)	Weaning weight (lbs.)	Type score	Condition score	Neck folds score	Index
Inbred lines	1948	871	15.8	4.18	3.16	73.97	1.95	2.21	1.21	113.5
	1949	838	14.9	4.04	3.34	76.59	1.94	2.67	1.20	123.3
	1950	647	15.8	4.10	3.44	78.67	1.69	2.37	1.12	122.0
	1951	711	18.4	3.73	3.49	80.30	1.91	2.60	1.14	132.8
	1952	416	20.1	3.77	3.40	77.15	2.23	2.57	1.07	129.1
Non-inbred control	1948	180	1.9	4.01	3.31	72.70	1.92	2.32	1.23	116.5
	1949	189	1.9	4.06	3.53	75.25	1.89	2.70	1.20	123.2
	1950	170	1.9	3.69	3.54	78.50	1.67	2.40	1.16	128.9
	1951	215		3.35	3.60	79.96	1.89	2.61	1.13	139.1
	1952	130		3.50	3.58	76.84	2.32	2.53	1.10	133.5

As expected, there was little real difference in the two groups in the first 2 years. The control group had slightly longer staple, lighter weaning weights, better type and poorer condition. In the third year, when the effects of selection within the control group should have become apparent, there was definite improvement in face covering as compared with the inbred lines but little change in the relative gains for the other traits. In 1951 and 1952 the control group continued to excel in face covering, staple length and index but did not appear to be gaining on the inbred lines.

In past years 4 rams have been used in this control group a second year because their progeny ranked highest in the previous year. Two of these 4 rams ranked above average for progeny born in the second year but none excelled all other rams used. The average index of the progeny of tested sires was very slightly lower than the comparable average of all progeny in those years. Thus nothing was gained by using progeny tested sires in addition to the best young sires used. Theoretical studies have confirmed this.

RAMBOUILLET GENETICALLY STABILIZED CONTROL GROUP

A genetically stabilized control group, with artificial selection entirely at random, is being established to serve as a control for year to year environmental changes affecting the inbred lines and the selected group of Rambouillets. This random breeding group will also be used to obtain estimates of gains from selection by taking data from the group and applying various selection practices on paper; to obtain estimates, unbiased by selection, of relationships between traits, and of repeatabilities and heritabilities of all traits; and to provide an experimental group on which new methods of evaluation (new scores, measures, indexes, different methods of adjusting records, etc.) may be tested, unconfounded by selection, before applying them to the whole flock.

The first step in establishing this group was made this year with the random sorting out of half of the offspring from the selected control group. A total of 31 ram lambs and 34 ewe lambs at weaning time in 1952 were designated for this group. One-half of the offspring of the selected control group will continue to be sorted out until 100 ewes of breeding age are obtained. Normal practice will be followed at birth. No culling will be practiced after birth except that when the number of ewes of breeding age reaches 100, the oldest ewes will be culled by whole age groups each year to reduce the numbers to 100 ewes. Where part of an age group needs to be culled they will be sorted out at random. Rams over one year of age will be culled after use in breeding as yearlings and after needed estimates of repeatability have been obtained. When the ewes reach breeding age they will be pen-mated at random to 20 yearling rams originally sorted out from the selected control group and later produced from the genetically stabilized control group. At the beginning, when the number of breeding ewes is less than 100, one ram will be bred to each group of about 5 ewes. All ram lambs will be kept to yearling age and rams to be mated will be sorted out at random from all yearlings available in the group.

INCREASING ACCURACY OF SELECTION OF COLUMBIAS

Indexes were developed during the year for Columbia lambs and for yearling and mature Columbia rams. The use of an index is a more efficient way to select for superiority of several traits than the use of independent culling levels or selection for one trait at a time. Furthermore an index permits a constant and objective degree of emphasis on each trait which is important in selection. Thus selection ideals are held constant from year to year and more important traits can receive the extra attention they deserve. Degree of emphasis for each trait in these indexes is based on heritability and economic importance. Estimates of variability of each trait and relationships to other traits are also used in calculating the indexes.

The index for weanling lambs equals 10 times staple length in centimeters minus 5 times side grade code plus weaning weight in pounds plus 6 times type score plus 3 times condition score ($Ix=10L - 5SGC + W + 6T + 3C$) The side grade code ranges from 1 to 9 for fleeces grading 70's to 46's, respectively.

Adjustments were applied directly to the index for the effects of inbreeding, age at weaning, type of birth, age of dam, and weaning band on the traits included. Selections were made on the basis of this index in the fall of 1951.

The index developed for Columbia rams equals grease fleece weight in pounds plus 18 times clean fleece weight in pounds plus 2 times staple length in centimeters minus 2.5 times fleece grade code plus body weight in pounds plus 6 times type score plus 3 times condition score ($Ix = G + 18Cl + 2L - 2.5FGC + W + 6T + 3C$). The fleece grade code is based on spinning counts as at weanling age except that code 10 for 44's is added. Life-time averages are obtained for each ram trait after adjustment for age, year, previous selection, number of records, inbreeding and other important environmental effects. Then the index is applied directly to the adjusted lifetime averages.

SELECTION PRACTICED ON WEANLING LAMBS

Weanling selection differentials represent the average differences between selected lambs and all lambs weaned, after corrections for environmental influences have been made. Considerable selection is practiced on rams at later ages but most of the effective selection of ewes for fleece and body traits is made at weanling age. The relative emphasis on each trait was obtained by dividing the selection differential by the standard deviation for each breed.

Heritability estimates were obtained from 1941 and 1942 weanling lambs for Rambouillets and from 1941 to 1944 weanling lambs for Columbias and Targhees. Average estimates from Corriedale, Columbia and Targhee lambs were used for the latter two breeds as there were insufficient numbers within each breed to obtain reliable estimates.

The expected genetic gain per generation for each sex is the selection differential times one-half of the heritability. The sum of the products for both sexes gives the expected genetic gain per generation from selection practiced at weanling age on both sexes. These are relative gains

because not all lambs saved at weaning will be used in breeding or will produce offspring.

Annual genetic improvement, estimated from selections at weanling age, depends partly on the length of the generation interval, which is the average age of the parents when their offspring are born. The estimated annual genetic improvement resulting from weanling selections is the expected gain per generation from selection of both sexes divided by the generation interval. The generation interval which should be applied to these data would be the age when these offspring produce progeny. This can only be estimated now from the average age of the present parents.

Rambouillets

The proportion of lambs saved from inbred lines was less in 1951 than in 1950 probably because of the larger lamb crop in 1951. In 1951, 38% of the ram lambs and 68% of the ewe lambs were saved as compared with 40% and 78% and 32% and 69%, respectively for 1950 and 1949. Selection differentials and expected gains from weanling selections in Rambouillet inbred lines in 1951 are shown in the following table:

	Face covering score	Staple length (cm.)	Weaning weight (lbs.)	Type score	Condition score	Neck folds score	Index
Heritability	56%	40%	30%	13%	4%	39%	30%
RAMS							
Selection differential	.24	.07	4.16	.26	.11	.09	8.26
Expected genetic gain per generation	.067	.014	.624	.017	.002	.018	1.239
EWES							
Selection differential	.11	.05	1.31	.10	.08	.06	3.29
Expected genetic gain per generation	.031	.010	.196	.006	.002	.012	.494
RAMS & EWES							
Expected genetic gain per generation	.098	.024	.820	.023	.004	.030	1.733
Selection differentials expressed as fractions of a standard deviation							
RAMS	.39	.15	.49	.54	.26	.30	.55
EWES	.18	.11	.15	.21	.19	.20	.22

Selection differentials for Rambouillet lambs in 1951 were lower for face covering and were higher for weight, type and neck folds than in 1950. Increases would be expected because of the lower proportions saved. Relative emphasis was highest for index, as would be expected, although that for type score was only very slightly lower. There appears to have been an increase in emphasis on type and weight as compared with 1950.

The average ages of Rambouillet sires and dams when their offspring were born, for all lambs weaned, are given in the following table:

Year lambs were born	Average age of: Sires (years)	Dams (years)	Sires & dams (years)
1944	3.42	4.36	3.890
1945	3.45	4.28	3.865
1946	2.72	4.31	3.515
1947	2.38	4.31	3.345
1948	1.96	4.26	3.110
1949	2.23	4.26	3.245
1950	2.47	3.95	3.210
1951	2.10	4.24	3.170

Generation length based on both sires and dams was lower in 1951 than in any previous year except 1948.

The estimated annual genetic gains from weanling selections of Rambouillets from 1944 to 1951 are shown in the following table:

Year	Face covering score	Staple length (cms.)	Weaning weight (lbs.)	Type score	Condition score	Neck folds score	Index
1944	.019	.011	.223	.009	.002	.029	.586
1945	.024	.014	.306	.011	.002	.019	.628
1946	.041	.015	.325	.006	.002	.017	.737
1947	.040	.015	.374	.007	.001	.018	.851
1948	.034	.015	.383	.008	.002	.006	.707
1949	.032	.014	.339	.006	.002	.009	.655
1950	.034	.009	.239	.006	.001	.006	.547
1951	.031	.008	.259	.007	.001	.009	.547

The rates are lower in 1951 than for most of the years since 1946 for face covering, staple length and weaning weight. These traits receive considerable emphasis in the index. Some reduction in emphasis on the index is shown by a decrease in the expected genetic gain for index since 1947. Lack of change in 1951 over 1950 appears to be due to the shorter generation length for 1951. These genetic gains can be altered by later selections although the opportunity for later selections is often limited by the selection practiced at weaning age.

Targhees

A lower proportion of Targhee lambs of both sexes were saved in 1951 than in 1950. In 1951, 52% of the ram lambs and 67% of the ewe lambs were saved as compared with 54% and 75%, and 37% and 59% respectively for 1950 and 1949. Selection statistics for Targhee weanling lambs from inbred lines in 1951 are given in the following table:

	Face covering score	Staple length (cms.)	Weaning weight (lbs.)	Type score	Condition score	Neck folds score
Heritability	46%	43%	17%	7%	21%	8%
RAMS						
Selection differential	.14	.07	1.57	.11	.07	.08
Expected genetic gain per generation	.032	.015	.133	.004	.007	.003
EWES						
Selection differential	.08	-.03	2.02	.08	.12	00
Expected genetic gain per generation	.018	-.006	.172	.003	.013	00
RAMS & EWES						
Expected genetic gain per generation	.050	.009	.305	.007	.020	.003
Selection differentials expressed as fractions of a standard deviation						
RAMS	.24	.16	.16	.24	.14	.27
EWES	.14	-.07	.20	.17	.24	00

Selection differentials for weanling Targhees were generally lower than last year for ram lambs but were higher for weight, type and condition of ewe lambs than for last year. Relative emphasis in ram lambs was greatest for neck folds followed by type and face covering while greatest emphasis in ewe lambs was placed on condition followed in order by weight and type.

The average age of Targhee sires and dams when their offspring are born are given in the following table:

Year lambs were born	Average age of: Sires (years)	Dams (years)	Sires & dams (years)
1944	2.90	4.27	3.588
1945	2.15	4.52	3.334
1946	3.32	4.52	3.916
1947	2.39	4.32	3.355
1948	2.02	3.97	2.992
1949	2.36	3.75	3.059
1950	2.06	3.82	2.940
1951	2.15	4.15	3.150

The generation length in Targhees increased this year for both sires and dams and was longer than for any year since 1947. The age distribution in new Targhee lines is becoming stabilized and the increase in Targhee numbers is being achieved partly by retaining more older ewes.

The estimated annual genetic gains for Targhees from weanling selections from 1944 to 1951 are shown in the following table:

Year	Face covering score	Staple length (cms.)	Weaning weight (lbs.)	Type score	Condition score	Neck folds score
1944	.009	.009	.085	.003	.006	.002
1945	.021	-.001	.095	.004	.010	.002
1946	.008	.013	.115	.003	.006	.001
1947	.026	.017	.156	.002	.010	.001
1948	.027	.007	.127	.002	.003	.001
1949	.031	.019	.235	.005	.014	.002
1950	.029	.005	.137	.003	.008	.001
1951	.016	.003	.097	.002	.006	.001

In 1951 these rates again decreased for every trait except neck folds as in 1950. This occurred in spite of the lower proportions saved in 1951 as compared with 1950. This change is not all due to the difference in generation length as the expected gain per generation was also less in 1951 than in 1950 for every trait except neck folds. It is possible that these traits were less variable in 1951 or that more attention was paid to other traits.

Columbias

Fewer Columbia lambs of both sexes were saved in 1951 than in 1950. In 1951, 54% of the ram lambs and 62% of the ewe lambs were saved as compared with 75% and 76% and 50% and 69%, respectively, for 1950 and 1949.

Selection statistics for Columbia weanling lambs in 1951 are given in the following table:

	Face covering score	Staple length (cms.)	Weaning weight (lbs.)	Type score	Condition score	Side grade code
Heritability	46%	43%	17%	7%	21%	30%
RAMS						
Selection differential	.18	.04	3.52	.16	.11	-.10
Expected genetic gain per generation	.041	.009	.299	.006	.012	-.015
EWES						
Selection differential	.08	.04	3.32	.14	.19	.03
Expected genetic gain per generation	.018	.009	.282	.005	.020	.005
RAMS & EWES						
Expected genetic gain per generation	.059	.018	.581	.011	.032	-.010
Selection differentials expressed as fractions of a standard deviation						
RAMS	.43	.05	.30	.36	.22	-.09
EWES	.19	.05	.28	.32	.37	.03

Selection differentials were definitely higher than in the previous year. This may be due both to a lower proportion saved and to the use of an index for Columbia lambs for the first time this year. The expected genetic gain per generation was, of course higher in 1951 than in 1950. In the case of staple length, weaning weight, type and condition the gain in 1951 was at least double that for 1950. There was a slight tendency to favor the ram lambs with coarser wool in spite of the index.

The average age of Columbia sires and dams when their offspring were born are given in the following table:

Year lambs were born	Average age of: Sires (years)	Dams (years)	Sires and Dams (years)
1944	2.55	3.98	3.265
1945	2.87	4.12	3.495
1946	2.83	4.26	3.544
1947	2.62	4.36	3.490
1948	2.30	4.30	3.296
1949	2.38	4.41	3.396
1950	2.32	4.58	3.450
1951	2.28	4.83	3.555

The average age of Columbia sires in 1951 was the lowest to date while the average age of dams was the highest recorded in recent years. The decrease in age of sires has come about probably because of a desire to shorten generation length and also because the method of adjustment of records used in recent years allows a fairer comparison of rams of different ages. This change to younger sires has occurred in all 3 breeds. The increase in age of Columbia dams has probably come about because of an attempt to maintain numbers in spite of a relatively low reproductive rate and a fairly high culling rate for ewe lambs. Columbia dams in 1951 average about 0.8 year older than in 1944 and 0.6 and 0.7 year older than Rambouillet and Targhee dams respectively in 1951. The generation length has been longer for Columbias than for Rambouillets and Targhees since 1947.

The estimated annual genetic gain for Columbias from weanling selections from 1944 to 1951 are shown in the following table:

Year	Face covering score	Staple length (cms.)	Weaning weight (lbs.)	Type score	Condition score	Side grade code
1944	.007	.005	.076	.002	.004	
1945	.018	.013	.171	.004	.011	
1946	.014	-.001	.087	.002	.006	
1947	.010	.003	.121	.001	.006	
1948	.009	.001	.074	.002	.006	
1949	.005	-.001	.158	.003	.009	
1950	.010	-.003	.075	.001	.004	
1951	.017	.005	.163	.003	.009	-.003

These rates showed increases in 1951 over 1950 and most previous years for every trait in spite of the longer generation interval. These gains may be attributed to year to year changes or to the use of an index for the first time in 1951.

OPTIMUM SELECTION AND MATING PROCEDURES FOR RANGE SHEEP

A study was undertaken to determine, on a theoretical basis, what selection and mating procedures would be optimum for intra-flock improvement of sheep in various kinds of flocks. Preliminary results were obtained for a flock of 5000 breeding ewes of Columbia type where the rancher wished to establish a selected flock composed of a few hundred of the best ewes from which the 150 rams needed for breeding would be produced. Assumptions included a 100 percent lamb crop, annual replacement of 30 percent of breeding ewes and selection for a single, normally distributed trait or index with a heritability of 30 percent.

Optimum selection and mating procedures include the maintenance of as large a selected flock as possible. Intense selection of ewes to start the selected flock is less important than initiating a flock large enough to permit adequate selection of the ram offspring needed for breeding. The flock size which approaches the optimum becomes larger as the number of rams needed increases.

Random mating probably should be used among selected individuals and the selected flock should not be split into non-interbreeding subgroups. Pen mating is unnecessary except for record purposes. Rams should be selected on the basis of their own phenotype at a particular age. A high proportion of rams used should be yearlings. Progeny testing is only slightly helpful for weanling traits and would retard progress for yearling traits which have heritabilities of 30 percent or more. Therefore, the rancher was advised to select the smallest possible number of his best yearling rams to breed the selected flock.

Selection of original and replacement ewes should be made on the basis of phenotype at a particular age. Relatively few yearling replacements for the selected flock should come from the main flock despite the higher apparent merit of many of the latter. It is concluded that ranchers can make progress in improving their sheep by using a relatively small selected flock for the production of rams and by using mass selection techniques on this flock.

THE EFFECT OF SELECTION ON THE INCIDENCE AND HERITABILITY OF NECK FOLDS IN RAMBOUILLET WEANLING LAMBS

A study was made to determine the actual effectiveness of selection against neck folds and its relation to estimates of heritability in Rambouillet weanling lambs. Scores for neck folds were analyzed from 5083 ram and 5619 ewe lambs born from 1938 through 1951 in one-sire inbred lines. Selection against neck folds resulted in a definite decrease in average neck folds from moderate folds in 1938 to very slight folds in 1951. The average annual decrease was about 0.1 score. Selection differentials were usually higher for sires than for dams. Expected gains from selection of sires were also greater than from dams because of the shorter generation lengths for sires. Selection differentials generally increased to 1944 and then declined with the reduced incidence of neck folds in the later years.

Heritability estimates from half-sib correlations were high (0.21 to 1.15) through 1944 and then declined and remained low (0.05 to 0.19) through 1951, with one exception. In the later years, genetic variation among sires was apparently largely removed by the selection practiced. Heritability estimates from intra-sire regressions of offspring on dam fluctuated from 0.18 to 0.63 and followed no definite trend. They were definitely higher than half-sib estimates after 1943. Estimates of heritability from the ratio of actual gains to selection differentials were abnormally high, being above unity for 8 of the 12 years. The results indicate that neck folds of weanling Rambouillet lambs can be removed rapidly by selection. However, the rate of improvement obtained in this study was more rapid than had been expected on the basis of heritability estimates. Changes in scoring standards offer a possible explanation for the discrepancy.

THE RELATION BETWEEN SALE PRICE AND MERIT IN COLUMBIA, TARGHEE AND RAMBOUILLET RAMS

A study was made on the relation of sale price to records of merit as an estimate of the value attached to improvement in these traits by the buyers of stud rams. In addition, indications of possible ways to encourage the use of production records in the improvement of sheep were sought. A total of 202 Columbia, 104 Targhee and 59 Rambouillet single stud rams sold at public auction from 1946 through 1951 were included.

Significant correlations with price were obtained for body weight, grease fleece weight, clean fleece weight, type score, condition score, index and order of sale. Low and non-significant correlations with price were obtained for staple length, fleece fineness and face covering. The low correlation of price with face covering in Rambouillets may be due to differences in merit for other traits and to possible changes in face covering from scoring time to sale time.

Type of birth had a significant effect on prices of yearling Columbia rams but not on prices of yearling Targhees. Age in days of yearling rams, age in years of mature rams and age of dam had no consistent relationship with price. There was no evidence of any real difference

between the prices of Columbia and Targhee rams with scurs and those which were strictly polled. Polled Rambouillet rams sold for higher prices than horned rams in 4 out of 5 groups. Registered Rambouillet rams brought higher prices than unregistered rams in 2 out of 3 groups.

The results indicate that buyers of stud rams attach real importance to production traits such as body weight, fleece weight and mutton conformation. The presentation of more information on sale rams, particularly for those traits which are difficult to appraise visually, appears to be desirable. It also seems advisable to present a selection index for each sale ram so that the buyer can take full advantage of the available records on each ram.

LAMB PRODUCTION

A summary of lamb production for inbred lines in the three breeds is presented in the next table. The percent of ewes lambing is based on ewes bred and present at lambing. This may be an indication of ram fertility although the fertility of the ewes also affects it. The percent of lambs born of ewes lambing is based on all lambs born, alive or dead, of ewes actually having lambs. This value minus 100 gives the percent of ewes having twins. The percent of lambs born which were alive and the percent of live lambs which were weaned are measures of lamb mortality at birth and from birth to weaning respectively. The percent of lambs weaned of ewes bred is a combination of the first four values plus any effect of ewe loss after breeding. Weaning weights are taken when it is necessary to remove ram lambs to prevent them from breeding ewes which is somewhat earlier than customary marketing time. Average age at weaning has decreased in recent years because of slight changes in breeding and weaning dates. The average weaning ages in 1951 were 126, 114 and 115 days and in 1952 were 126, 116 and 116 days for Rambouillets, Targhees and Columbias, respectively. Pounds of lamb per ewe bred is an overall value that is a combination of the other individual measures. Breeds are not directly comparable because of differences in age of ewes, breeding and weaning dates, etc. Some changes in age of ewes, breeding and weaning dates, etc. occur from year to year.

Lamb production was very good in 1951. In Columbias and Targhees most attributes of lamb production were higher in 1951 than in any previous year. However, 1952 was one of the poorest years in lamb production because of losses due to Vibrio infection. Percent of lambs born of ewes lambing, percent of lambs weaned of live lambs born, and weaning weights were fairly normal in 1952.

Lamb Production

Year	No. of ewes bred	Percent of ewes lambing	Percent lambs born of ewes lambing	Percent of live lambs born of lambs born	Percent of lambs weaned of live lambs born	Percent of lambs weaned of ewes bred	Average weaning weight in pounds	Pounds of lamb per ewe bred
Rambouillet Lines								
1940-44	4489	90.6	127.6	92.9	86.6	91.9	77.7	71.4
1945	898	92.7	124.0	94.4	87.4	93.5	69.5	65.0
1946	890	94.3	134.5	94.6	86.4	100.7	70.8	71.4
1947	897	90.0	124.1	94.6	86.2	88.3	70.6	62.4
1948	882	93.6	130.7	94.9	86.2	98.8	66.3	65.4
1949	1002	90.4	128.4	93.2	81.1	86.1	69.5	59.8
1945-49	4569	92.2	128.0	94.3	85.4	93.3	69.3	64.7
1950	851	89.1	119.6	94.5	79.6	76.0	70.5	53.6
1951	806	91.3	133.8	94.2	78.7	89.3	72.0	64.3
1952	739	88.9	123.1	68.2	77.5	56.8	67.4	38.3
Targhee Lines								
1941-44	800	92.2	128.7	93.6	78.9	86.5	72.6	62.8
1945	257	88.4	127.9	96.1	84.4	84.4	71.7	60.5
1946	245	95.8	130.6	96.0	76.3	89.4	72.1	64.4
1947	299	93.2	118.9	91.4	78.6	78.6	74.6	58.6
1948	288	92.2	127.1	90.7	83.1	87.2	72.5	63.2
1949	408	88.6	122.5	96.0	81.8	82.8	77.6	64.3
1945-49	1497	91.4	124.9	94.1	80.0	84.2	74.0	62.3
1950	420	95.2	128.1	92.5	85.0	94.8	73.8	70.0
1951	434	94.1	140.8	95.4	86.2	106.7	74.5	79.5
1952	476	71.4	124.5	65.6	86.1	48.3	73.2	35.4
Columbia Lines								
1941-44	1294	86.7	126.0	90.7	80.5	78.0	78.5	61.3
1945	378	90.7	128.5	93.5	78.5	83.1	73.0	60.6
1946	448	89.4	130.9	90.6	68.7	70.5	72.6	51.2
1947	455	82.7	118.7	79.6	74.6	56.9	76.0	43.2
1948	320	88.3	124.6	85.7	80.3	75.0	74.3	55.8
1949	381	88.9	126.1	90.1	73.5	72.2	80.0	57.7
1945-49	1982	87.8	125.9	88.0	74.7	70.8	75.0	53.2
1950	343	87.2	127.7	91.2	80.6	79.9	76.6	61.2
1951	355	93.3	136.6	94.3	81.4	95.2	76.4	72.7
1952	331	68.2	124.4	69.4	78.0	45.0	73.0	32.9

LAMB MORTALITY IN RANGE SHEEP

A preliminary study was made of lamb mortality in the Station flocks of Columbia, Targhee and Rambouillet sheep. Lamb mortality can be divided into two periods from routine records, namely, lambs dead at birth and lambs dying from birth to weaning. These mortalities are expressed in terms of survival as percent lambs born alive of lambs born, and percent lambs weaned of lambs born alive.

The percent of lambs born alive, of lambs born, was 93.2 for the entire flock from 1941 to 1949. The percent of lambs weaned of live lambs born was 83.8 and of all lambs born was 78.1 for the same period. There was little evidence of any trend in mortality over these years although the percent of lambs weaned of live lambs born was slightly higher from 1940 to 1944 than from 1945 to 1949.

Generally over half of the lambs born dead appeared to be immature at birth. In recent years lambs sold as orphans, because their mothers could not raise them, accounted for about 3.4 percent of lambs born alive.

The relation of lamb mortality to inbreeding was observed for 2-year old Rambouillet ewes, lambing from 1949 to 1951 in inbred lines. The average coefficient of inbreeding of lambs weaned was 20.3 percent as compared with 24.7 percent of lambs dead at birth and 23.0 percent for lambs lost from birth to weaning (including those sold as orphans). Thus, on the average, lambs which were not weaned were more highly inbred than lambs which were weaned.

Sire and line differences in percent of lambs weaned of all lambs born within breeds and types of mating were analyzed for the years 1947 and 1951. The percent of lambs weaned of all lambs born was 75.2 for 1947 and 79.6 for 1951. Significant sire or line differences were found only in Rambouillet and Targhee inbred lines in 1947. No other significant sire or line differences were found in either year. Line differences could be a reflection not only of sire differences but also of differences in levels of inbreeding, and in environmental factors such as age of dam. The absence of real sire differences in test and cross line matings where the ewes are sorted at random to the sires indicates that selection against lamb mortality would appear to be largely ineffective. However, selection would likely be more effective under conditions that would lead to high mortality.

A modification has been made in the system of recording deaths of lambs after birth so that in the future it will be possible to determine the periods between birth and weaning in which mortality is highest.

OCCURRENCE OF IMMATURE LAMBS

Records of ewes having immature lambs have been summarized from 1940 through 1952. The percentage of ewes present at lambing and having immature lambs was 26.2 in 1952, when the organism, vibrio fetus, was found in some aborted fetuses, as compared with an average percentage of 3.5 from 1940 through 1951. The percentage of ewes dropping immature lambs was

slightly higher in more recent years, averaging 4.2 for the years 1947 through 1951. Somewhat higher proportions of ewes with immature lambs occurred in 1941 and 1947 with 6.6 and 6.4 percent, respectively. It is remembered that appreciable numbers of ewes had immature lambs in 1937 but records are not readily available for that year. The losses in 1937 were attributed to the feeding of moldy hay.

The following table shows losses in 1952 as compared with the years 1947 through 1951:

Breed		Percent ewes with live lambs	with dead lambs	with immature lambs	Dry	% dead lambs of lambs born exclusive of immature lambs	% lambs weaned of live lambs born
Rambouillet	1952	62.1	3.1	28.4	6.4	5.8	80.2
	1947-51	87.2	1.7	2.6	8.5	2.6	83.9
Targhee	1952	49.2	1.9	25.2	23.7	5.3	87.3
	1947-51	85.3	2.0	4.0	8.7	2.6	84.8
Columbia	1952	45.1	2.8	22.2	29.9	5.4	81.5
	1947-51	78.7	2.7	7.4	11.2	4.0	79.9

More Rambouillet ewes had dead lambs (mature) in 1952 than in previous years and a higher proportion of dead lambs occurred in all 3 breeds. This may have resulted from misclassification of immature lambs as dead lambs as there was little evidence of lowered viability from birth to weaning. Rambouillets weaned a slightly lower proportion of lambs in 1952 than in previous years but Columbias and Targhees weaned higher proportions.

The proportion of ewes with immature lambs was highest for Rambouillets and lowest for Columbias while the proportion of dry ewes (no lamb born) was highest for Columbias and lowest for Rambouillets. These differences are significant. There was opportunity for misclassification as to whether the ewe had an immature lamb or was dry as the decision was often based on very meager evidence. However, one Targhee and one Columbia pen were completely dry. In addition a number of ram lambs were used in all of the breeds. It was noted that in pens bred to ram lambs the proportion of ewes with immature lambs was uniformly lower and the proportion of dry ewes was higher than in the entire breed groups. Again this may indicate some misclassification. Another table follows for 1952 data with dry pens and pens bred to ram lambs eliminated:

Breed	Percent ewes with live lambs	with dead lambs	with immature lambs	Dry	% dead lambs of lambs born exclusive of immature lambs	% lambs weaned of live lambs born
Rambouillet	63.3	3.0	28.3	5.4	5.7	79.9
Targhee	52.1	2.1	25.8	20.0	5.5	86.4
Columbia	47.0	2.9	23.2	26.9	5.4	82.1

It is apparent that the relationships are much the same as in the previous table. It appears that Targhees and Columbias, which were bred 18 days later than the Rambouillets, had slightly fewer ewes with immature lambs and considerably more dry ewes than Rambouillets. This may have been caused by more early prenatal death and fetal resorption in the Targhees and Columbias than in the Rambouillets. This is logical if both bands were infected at the same time since the Targhees and Columbias would be at an earlier stage of gestation. Also, it is possible that more of the Targhees and Columbias that actually gave birth to immature lambs were classified as dry.

Tests of significance (Chi-square tests of homogeneity) within types of mating (inbred lines, test pens, etc.) failed to reveal any significant differences in the proportions of immature lambs dropped by ewes in different breeding pens. There was only 1 pen(excluding the dry pens) that did not have at least 1 ewe drop an immature lamb, and this pen contained only 12 ewes.

The percentages of lambs weaned of ewes bred were 59.4, 56.2 and 46.9 for Rambouillets, Targhees and Columbias, respectively, in 1952. The percentage for the entire flock in 1952 was 57.8 as compared with 90.5 for the years 1947-1951.

The percentages of ewes persent at lambing that had immature lambs and the percent that were dry are given in the following table for various ages of ewes in 1951 and 1952.

Percentages of ewes with immature lambs (dry pens excluded)

Breed	Year	No. ewes present	Age of ewes in years							
			2	3	4	5	6	7	8	9
Columbia	1951	554	4	9	2	0	0	4	5	0
	1952	524	31	23	20	21	6	14	26	33
Targhee	1951	667	1	4	4	1	1	0	0	0
	1952	676	24	31	28	27	18	7	20	0
Rambouillet	1951	1302	3	6	2	0	1	0	0	0
	1952	1252	31	31	28	24	18	12	10	0
		Percent ewes dry (dry pens excluded)								
Columbia	1951	554	10	16	9	3	2	0	0	33
	1952	524	29	40	22	27	19	11	10	0
Targhee	1951	667	8	6	2	2	2	0	14	0
	1952	676	29	14	21	27	8	2	7	0
Rambouillet	1951	1302	5	3	5	0	5	2	6	0
	1952	1252	9	7	6	8	2	2	10	0

Loss of ewes by death appeared to be higher than normal in 1952. The percentage of ewes that were dead or missing of ewes bred was 9.0 in 1952 as compared with 6.6 in 1951. In 1952, ewes that had immature lambs and died before July 1 represented 0.75 percent of ewes bred. In addition 1.9 percent of ewes bred died between March 1 and June 1 and had no lambing record. Most of the ewes which died following the birth of immature lambs probably received no lambing record. It seems likely that the death loss of ewes was somewhat higher as a result of the outbreak of vibriosis.

RAM SEMEN TESTS FOR 1951

The semen of 188 rams (lambs, yearlings and mature rams) was examined before the beginning of the 1951 breeding season. The table on the next page shows that 138 or 73 percent of these were considered to have semen of acceptable quality after the first test (3 consecutive ejaculates). Fifty rams had semen ranging from borderline to definitely poor quality. Thirty-three of these 50 rams were retested after which 12 were considered to be potentially fertile and 21 were considered to be poor breeding risks. The other 17 rams were not retested either because they were not needed for use in breeding or because their semen was of such poor quality on the first test that further testing appeared to be useless. Twenty-two rams of yearling age or older and 53 lambs refused to serve under the conditions that prevailed during testing.

On the basis of all rams tried 84% of 49 rams two years old and older, had semen of acceptable quality, 14% had semen of borderline to definitely poor quality and 2% refused to serve. Corresponding figures are 56%, 27% and 17% for 125 yearling rams and 30%, 10% and 60% for 89 ram lambs. There were no striking breed differences or breed x age interactions noted.

One hundred and seventeen of these rams were used in breeding. The following table shows that 2 of them failed to sire any lambs and 29 (25%) settled all the ewes to which they were bred. About 68 percent settled 80

Distribution of Percentages of Ewes Lambing

		Pens having a percentage of ewes lambing of:						
Breed		1-19	20-39	40-59	60-79	80-99	100	Total
Rambouillet	No.	0	1	1	6	32	24	64
	Percent	0	1.6	1.6	9.4	50.0	37.5	
Targhee	No.	1	1	0	2	12	15	5	36
	Percent	2.8	2.8	0	5.6	33.3	41.7	13.9	
Columbia	No.	1	0	1	1	10	4	0	17
	Percent	5.9		5.9	5.9	58.8	17.6	0.0	
ALL	No.	2	1	2	4	28	51	29	117
	Percent	1.7	0.9	1.7	3.4	23.9	43.6	24.8	

percent or more of their ewes and about 92 percent settled more than 60 percent. Fourteen rams that were considered to have semen of borderline quality at the time of use were used in breeding. Of these, 7 settled more than 80 percent of their ewes, 5 others had conception rates ranging from 73 to 78 percent, one ram had a conception rate of 55 percent and one was sterile. Ten rams were used that had semen of borderline to poor quality on their first test but were considered to be potentially highly fertile at time of use (after retesting). Of these, 2 had conception rates of 100 percent, 5 had conception rates ranging from 87 to 97 percent, and the remaining 3 had conception rates of 64, 36, and 9 percent.

SUMMARY OF SEMEN TESTS - 1951

Breed	Age	No. of rams tried	Number refusing to serve		First Test: Number tested	First Test: Rams having semen of: Acceptable quality		First Test: Rams having semen of: Borderline to poor quality		Second Test: Number tested	Second Test: Rams having semen of: Acceptable quality		Second Test: Rams having semen of: Borderline to poor quality	
			No.	%		No.	%	No.	%		No.	%	No.	%
Rambouillet	5	0												
	4	4	0	0.0	4	4	100.0	0	--	0	--	--	--	--
	3	5	0	0.0	5	4	80.0	1	20.0	1	1	100.0	0	
	2	28	0	0.0	28	23	82.1	5	17.9	5	1	20.0	4	80.0
	1	57	15	26.3	42	30	71.4	12	28.6	8	3	37.5	5	62.5
	L	54	37	68.5	17	11	64.7	6	35.3	0				
TOTAL	All	148	52	35.1	96	72	75.0	24	25.0	14	5	35.7	9	64.3
Targhee	5	1	0	0.0	1	1	100.0	0	--	0	--	--	--	--
	4	0												
	3	3	0	0.0	3	2	66.7	1	33.3	1	0	0.0	1	100.0
	2	5	1	20.0	4	4	100.0	0	--	0	--	--	--	--
	1	47	3	6.4	44	27	61.4	17	38.6	13	4	30.8	9	69.2
	L	27	13	48.1	14	12	85.7	2	14.3	1	1	100.0	0	
TOTAL	All	83	17	20.5	66	46	69.7	20	30.3	15	4	26.7	11	73.3
Columbia	5	0												
	4	0												
	3	1	0	0.0	1	1	100.0	0	--	0	--	--	--	--
	2	2	0	0.0	2	2	100.0	0	--	0	--	--	--	--
	1	21	3	14.3	18	13	72.2	5	27.8	3	1	33.3	2	66.7
	L	8	3	37.5	5	4	80.0	1	20.0	1	1	100.0	0	
TOTAL	All	32	6	18.8	26	20	76.9	6	23.1	4	2	50.0	2	50.0
ALL	5	1	0	0.0	1	1	100.0	0	--	0	--	--	--	--
	4	4	0	0.0	4	4	100.0	0	--	0	--	--	--	--
	3	9	0	0.0	9	7	77.8	2	22.2	2	1	50.0	1	50.0
	2	35	1	2.9	34	29	85.3	5	14.7	5	1	20.0	4	80.0
	1	125	21	16.8	104	70	67.3	34	32.7	24	8	33.3	16	66.7
	L	89	53	60.0	36	27	75.0	9	25.0	2	2	100.0	0	--
GRAND TOTAL	All	263	75	28.5	188	138	73.4	50	26.6	33	12	36.4	21	63.6

RELATIONSHIPS BETWEEN LIBIDO, SEMEN CHARACTERISTICS AND FERTILITY IN RANGE RAMS

This study which was reported in a preliminary way in the last report has been extended to cover the 15 year period of 1936-1950. In that time 1,109 rams, consisting mainly of the Rambouillet, Targhee, Columbia and Corriedale breeds, were mated in 1,309 pens to 31,473 ewes. Since some of the rams and most of the ewes were in the breeding flock for more than one year these figures are not the number of separate, individual animals included in the study but rather the number of independent observations for the various items studied.

The data indicated that libido, as measured by the time required to produce successive ejaculates and by the number of ejaculates produced in a 30-minute period, had a significant relationship to fertility.

Of the various semen characteristics studied (including viscosity, pH, volume of semen, motility score, percentage of motile sperm, estimated motility count, or EMC, sperm concentration, total sperm produced per trial, percentage of normal sperm, percentage of abnormal heads, percentage of live sperm and percentage of live-normal sperm) only volume of semen, EMC, percentage of normal sperm, percentage of abnormal heads and percentage of live-normal sperm were significantly correlated with the percentage of ewes lambing.

The same semen traits that were significantly associated with percentage of ewes lambing were also significantly correlated with percentage of live lambs probably because of the significant relationship between percentage of ewes lambing and percentage of live lambs.

Age of ram and inbreeding of ram were not significantly correlated with the percentage of ewes lambing but inbreeding of the ram did have a significant depressing effect on the percentage of live lambs and the percentage of lambs weaned of live lambs born.

DEVELOPMENT OF THE PENIS IN RAM LAMBS

The development of the penis was observed in ram lambs at weaning age to determine the amount of variation in penis development and to attempt to identify some of the causes of variation.

At birth the glans penis and processus urethra of the ram lamb are adhered to the preputial mucosa, the urethral process lying in a groove on the wall of the prepuce. The adhesions gradually break down as the lamb grows older so that the prepuce can be everted and the penis exposed. The developmental process can be divided into five fairly well-defined stages which were scored as follows: (1) infantile condition, (2) urethral process free, (3) tip of glans free, (4) free to below glans and (5) adult condition.

The stage of development was scored at weaning time, at ages of 91 to 155 days in 1250 ram lambs born in 1951. Although developmental scores of 3 and 5 were found in lambs 91 and 103 days old respectively, the organs of a number of the oldest lambs examined were still in an infantile condition.

There were significant breed differences in development; 278 Columbias and 359 Targhees, both weaned at an average age of 115 days, had mean scores of 2.45 and 2.37 respectively while 613 Rambouillets, weaned at an average age of 125 days, had a mean score of only 1.87. Corresponding standard deviations for the three breeds were 1.32, 1.20 and 1.09. The coefficients of variation were higher in inbreds than in outbreds of the same breed in Columbias and Rambouillets but not in Targhees.

Simple correlation coefficients of penis scores with other weanling traits were: age 0.092**; inbreeding, -0.086*; weight, 0.440**; condition, -0.270**; staple length, 0.175** and index, 0.308**. The negative correlation between penis score and condition indicates that penis scores were higher in the fatter lambs.

Lambs born and raised as singles and lambs born as twins but raised as singles had average penis scores of 2.30 and 2.32 respectively while lambs born and raised as twins had an average score of 1.88.

There was little difference in the average scores of lambs out of ewes from 2 to 7 years old except for lower scores of lambs from 6 year old ewes. Lambs from 8 to 9 year old ewes had much lower scores than lambs from younger ewes.

Heritability estimates obtained from half-sib correlations were quite variable for the various breeding groups and the standard errors were quite large.

An experiment conducted in 1952 indicates that the developmental process is under the control of the testis hormone. Development was arrested by castration and by the administration of the synthetic estrogenic hormone, dinesterol. Results of administering testosterone propionate to intact animals were inconclusive.

BIRTH COAT STUDY

Scores for amount of hair in the fleece and the covering of wool at birth were taken on lambs born in 1951. Distributions of lambs at birth and at weaning with the various scores for hair and wool covering are presented in the accompanying table.

The average hair covering scores were 2.16, 1.95 and 1.97 for Rambouillets, Targhees and Columbias, respectively, and the corresponding wool covering scores were 2.14, 2.29 and 2.37. Rambouillets tended to have slightly more hair and slightly less wool covering than the two coarser-wooled breeds.

Survival to weaning was slightly greater for the lambs with hair (scores 2 to 5) of which 84.7 percent of lambs born were weaned as compared with 80.4 percent of lambs with no hair (score 1). Lambs with medium wool covering (score 3) had a higher survival rate to weaning than those with less wool covering, although the small number with considerable wool (score 4) also had a lower survival rate.

Whether the amounts of hair and wool covering at birth actually affect survival or whether they are merely associated with some factor important to survival is not known. Data on individual gestation lengths may be needed to answer these questions.

Birth coat scores and their relatiohship to survival rates.

	Rambouillet			Targhee			Columbia			All Breeds		
Hair score	No. born	% of all lambs born	% weaned of lambs born	No. born	% of all lambs born	% weaned of lambs born	No. born	% of all lambs born	% weaned of lambs born	No. born	% of all lambs born	% weaned of lambs born
1	228	15.1	76.3	190	22.9	83.7	102	16.8	83.3	520	17.6	80.4
2	884	58.4	84.7	520	62.5	86.9	437	71.8	82.6	1841	62.3	84.8
3	332	21.9	84.0	100	12.0	86.0	60	9.9	86.7	492	16.6	84.8
4	69	4.5	80.0	20	2.4	90.0	8	1.3	87.5	97	3.3	82.5
5	2	0.1	100.0	2	0.2	50.0	2	0.3	50.0	6	0.2	66.7
Total	1515		83.1	832		86.1	609		83.1	2956		83.9
Wool score												
1	2	0.1	50.0	1	0.1	0.0	2	0.3	50.0	5	0.2	40.0
2	1295	85.5	82.9	604	72.6	85.1	400	65.7	81.0	2299	77.8	83.2
3	216	14.3	84.7	215	25.8	90.7	184	30.2	87.0	615	20.8	87.5
4	2	0.1	50.0	12	1.4	58.3	23	3.8	91.3	37	1.3	78.4
Total	1515		83.1	832		86.1	609		83.1	2956		83.9

SCOURABLE BRANDING FLUIDS

Tests were made on the durability of a scourable sheep branding fluid (formula G). Brands that had been applied just after shearing, about 11 months previous to checking, were legible on less than 10 percent of Columbia and Targhee ewes and on from 15 to 20 percent of Rambouillet ewes. Brands that had been applied in the fall, about 6 months previous to checking were legible on about 75 percent of Columbia and Targhee ewes and on about 90 to 95 percent of Rambouillet ewes.

Comparisons were made of the scourable sheep branding fluid (formula G) with a commercial branding fluid (advertised as scourable) applied to sheep from a cooperating rancher's flock. The brands were applied in June and both fluids were equally legible in October. At this time scourable fluid brands (formula G) were completely scourable while the commercial fluid brands were not. Some of both brands were legible the following June but it was not possible to determine the proportion of each kind that were legible.

These results indicate that this scourable branding fluid has sufficient durability for many uses but improvement of its durability would be desirable. Additional field tests should be made in commercial flocks to compare its durability with that of other common branding fluids.

FLEECE GRADES OF 1951 AND 1952 CLIPS

Grades have been assigned to whole fleeces at shearing time since 1942. It is probable that grading standards have not been constant during this time. Present standards place fleeces with spinning counts or U. S. numerical grades of 64's and finer and staple length of 2 1/2 inches or more into Fine Staple, and those of the same counts under 2 1/2 inches into Fine French. One-half Blood Staple includes counts of 60's and 62's with 3-inch length up to 1949 and 2 1/2 inches beginning in 1950. Three-eighths Blood includes counts of 56's and 58's with 3 inches required for staple length. Grades of 1/2 Blood French and 3/8 Blood French were assigned to a few fleeces in 1950 but not in other years so they have not been shown separately in the tables. Counts of 48's and 50's are included in 1/4 Blood, 46's in Low 1/4 Blood, 44's in Common and 40's and 36's in Braid.

Grades based on mean fiber diameter were obtained from cross sections of blended samples from the shoulder, back and hip. These have generally been obtained from all rams and all yearling ewes. However, data are incomplete for some past years. The conversion of mean fiber diameter to grades was shown in the Fourteenth Annual Report (1951).

The accompanying tables show the average fiber diameters based on cross-sections, the percentage distributions of grades based on visual grading of whole fleeces and the percentage distributions based on cross-section fiber diameter. The visual grades are those taken at shearing time in 1942 through 1950 and those taken at sorting time in 1951 and 1952.

Rambouillets

The following table shows that average fiber diameters for 1951 and 1952 were very similar to past years but were slightly smaller in 1952 than in 1951.

Average fiber diameter in microns for Rambouillets

	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952
Yr. ewes	20.28	20.57	21.53	21.48	21.01	21.98	21.75	21.46	21.59	21.52
Mat. rams	22.68	23.36	23.91	23.12	23.56	23.24	23.08	22.51	22.77	22.20
Yr. rams	21.94	21.55	21.28	21.06	20.87	21.70	21.21	21.64	21.46	21.08

Distributions of fleece grades show in general that a higher proportion of fleeces were placed in Fine French grades and a lower proportion in 1/2 Blood at sorting in 1951 and 1952 than at shearing in 1949 and 1950. The tendency to shift from 1/2 Blood to Fine in 1951 and 1952 was also shown in the distributions of fleece grades based on fiber diameter with the exception of mature rams in 1951. However, the grades based on fiber diameter classified a higher proportion of Rambouillet fleeces as 1/2 Blood than did visual grading.

Grades of Rambouillet Fleeces

	Distribution of Grades Based on Visual Grading										
	Years										
	1942 (%)	1943 (%)	1944 (%)	1945 (%)	1946 (%)	1947 (%)	1948 (%)	1949 (%)	1950 (%)	1951 (%)	1952 (%)
Mature ewes											
Fine French	70	39	36	39	19	34	40	43	30	48	37
Fine Staple	29	58	61	58	75	65	54	50	57	50	62
1/2 Blood	1	3	3	3	6	1	6	7	13	2	1
Yearling ewes											
Fine French	41	6	4	28	3	9	2	4	12	16	22
Fine Staple	58	88	92	66	91	88	91	90	76	84	76
1/2 Blood	1	6	4	6	6	3	7	6	12		2
Mature rams											
Fine French	15	7	3	2	4	2		10	5	11	7
Fine Staple	83	93	97	98	96	98	100	37	76	76	92
1/2 Blood	2							53	18	13	1
Yearling rams											
Fine French	11	6	2	2	7	9		6	5	26	13
Fine Staple	85	92	98	97	93	91	97	85	79	73	87
1/2 Blood	4	2		1			3	9	16	1	
	Distribution of Grades based on Cross-Section Fiber Diameter										
Yearling ewes											
Fine	91	92	78	78	84	62	77	93	91	96	
1/2 Blood	9	8	21	20	16	36	22	7	9	4	
3/8 Blood			1	2		2	1				
Mature rams											
Fine	57	25	27	36	31	34	44	62	48	80	
1/2 Blood	31	65	51	57	60	51	51	37	49	20	
3/8 Blood	11	10	20	6	8	14	5	1	3		
1/4 Blood	1		2	1	1						
Yearling rams											
Fine	69	87	83	86	83	71	96	94	98	99	
1/2 Blood	25	12	17	14	17	20	4	6	2	1	
3/8 Blood	6	1				9					

Targhees

Average fiber diameters for Targhees since 1943, as presented in the following table, do not show any definite trend in fineness:

Average Diameter in Microns for Targhees

	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952
Yr. ewes	23.22	23.26	24.17	24.48	22.34	24.12	23.66	23.56	23.74	23.26
Mat. rams	25.79	27.49	--	27.21	--	24.77	25.65	26.45	25.90	25.14
Yr. rams	24.51	24.39	--	22.48	--	23.70	22.79	23.05	23.30	23.69

Mature rams appear slightly finer as shown by average fiber diameter in 1952 but this may have been brought about by culling of the coarser rams as such a trend was not shown for yearling rams.

Distributions of visual grades and cross-section grades both showed some tendency to shift to the finer grades in 1951 and 1952 as compared with 1949 and 1950. However, this was not true of visual grades for mature rams in 1951 nor of cross-section grades for yearling rams in 1951 and 1952.

Columbias

Mean fiber diameters as shown in the following table showed little change in 1951 and 1952 over previous years:

Average Diameter in Microns for Columbias

	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952
Yr. ewes	27.16	25.88	26.61	26.88	--	27.02	25.67	25.16	26.29	25.93
Mat. rams	29.05	30.24	--	29.65	--	30.39	28.92	29.39	28.70	28.89
Yr. rams	27.74	27.39	--	25.62	--	26.59	25.81	25.65	25.68	25.76

Distributions of visual grades and cross-section grades for 1951 and 1952 were fairly consistent with past years. The tendency for yearling ewes to have finer fleeces from visual grading in 1951 and 1952 was not confirmed by cross-section grades. There was a low proportion of mature rams with 1/4 Blood fleeces in 1952 as compared with previous years. This was shown by both visual and cross-section grades. However, a shift to finer grades was not definite in either yearling rams or ewes.

Grades of Targhee Fleeces

Distribution of Grades Based on Visual Grading

	Years										
	1942 (%)	1943 (%)	1944 (%)	1945 (%)	1946 (%)	1947 (%)	1948 (%)	1949 (%)	1950 (%)	1951 (%)	1952 (%)
Mature Ewes											
Fine French	2		2	4	4	4	5	2	1		
Fine Staple	5	10	18	11	13	12	21	6	4	12	14
1/2 Blood	91	80	72	75	70	68	63	54	54	53	52
3/8 Blood	2	10	7	10	11	15	11	38	39	32	32
1/4 Blood			1		2	1		1	2	3	2
Yearling Ewes											
Fine French						2			1		
Fine Staple	2	2	14	9	8	19	16	12	16	16	17
1/2 Blood	82	83	75	79	76	64	73	46	61	73	73
3/8 Blood	16	15	11	11	16	14	9	40	21	10	10
1/4 Blood				1		1	2	2	1	1	
Mature Rams											
Fine French					3					2	
Fine Staple			6	9	6	9	8		2	4	
1/2 Blood	97	92	88	76	71	73	77	43	44	26	53
3/8 Blood	3	4	6	15	20	14	15	57	52	66	43
1/4 Blood		4				4			2	2	4
Yearling Rams											
Fine French							3				2
Fine Staple	2		14	10	8	12	27	13	4	31	15
1/2 Blood	98	62	72	72	81	64	60	75	51	59	70
3/8 Blood		38	14	18	11	22	10	11	44	10	12
1/4 Blood						2		1	1		1

Distribution of Grades Based on Cross-Section Fiber Diameter

Yearling Ewes										
Fine	33	34	5	1	61	19	26	15	18	25
1/2 Blood	63	54	81	82	38	59	62	80	77	71
3/8 Blood	4	12	14	17	1	21	12	5	5	4
1/4 Blood						1				
Mature Rams										
Fine	8			6		18			1	2
1/2 Blood	42	6		26		49	45	32	41	60
3/8 Blood	46	79		40		24	53	61	56	38
1/4 Blood	4	15		28		9	2	7	2	
Yearling Rams										
Fine	5	7		56		37	46	40	25	23
1/2 Blood	76	68		36		49	53	59	70	69
3/8 Blood	19	25		8		10	1	1	5	8
1/4 Blood						4				

Grades of Columbia Fleeces

Distribution of Grades Based on Visual Grading

	Years										
	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952
	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Mature Ewes											
1/2 Blood	12	3	6	3	3	3	3	4	3	2	2
3/8 Blood	53	58	55	48	47	47	45	42	48	50	44
1/4 Blood	32	37	37	48	48	48	46	50	41	47	53
L 1/4 Blood	3	2	2	1	2	2	6	4	8	1	1
Yearling Ewes											
Fine Staple										7	
1/2 Blood	7	3	7	4	4	6	7	9	19	26	24
3/8 Blood	75	61	72	57	42	63	67	70	70	60	62
1/4 Blood	18	35	20	39	53	30	25	19	11	7	14
L 1/4 Blood		1	1			1	1	2			
Mature Rams											
1/2 Blood	2		4	3		3				6	
3/8 Blood	61	52	74	47	26	40	50	61	52	33	68
1/4 Blood	37	48	22	50	74	55	46	39	33	52	32
L 1/4 Blood						2	4		14	9	
Com. & Br.									1		
Yearling Rams											
Fine Staple					1						1
1/2 Blood			9	8	5	3	5	11	2	11	23
3/8 Blood	80	48	65	53	57	56	72	77	85	69	58
1/4 Blood	20	48	26	38	37	40	23	11	13	20	8
L 1/4 Blood		4		1		1		1			

Distribution of Grades Based on Cross-Section Fiber Diameter

Yearling Ewes										
Fine	2	4			3	2		1	1	
1/2 Blood	15	36	16	4	26	38	62	29	40	
3/8 Blood	72	55	84	93	52	57	38	68	57	
1/4 Blood	10	5		3	18	3		2	2	
L 1/4 Blood	1				1					
Mature Rams										
Fine	3									
1/2 Blood	6				4		2	3		
3/8 Blood	43	30		40	23	51	35	65	68	
1/4 Blood	36	59		55	60	49	63	32	32	
L 1/4 Blood	12	11		5	4					
Com. & Braid					9					
Yearling Rams										
Fine				6	2	2	1		1	
1/2 Blood	24	14		40	28	35	43	34	36	
3/8 Blood	62	75		51	56	62	54	65	62	
1/4 Blood	9	9		3	14	1	2	1	1	
L 1/4 Blood	5	2								

SORTING OF 1951 CLIP

Some data from sorting of fleeces from the 1951 clip are summarized by breed, sex and age groups in the accompanying tables. This work was done in cooperation with the Wool Division, Livestock Branch, Production and Marketing Administration. Individual fleeces were sorted by one commercial wool sorter from the Wool Division. The matchings and off-sorts from each fleece were individually weighed, recorded and binned according to grade and staple length.

Fleeces of yearling ewes and rams had an average growth period of about 410 days. Fleeces of mature ewes and rams represent one year's growth. All mature ewes were crutched in March prior to shearing in May and approximately 1/2 pound of wool was clipped from each ewe.

Distribution of Main sorts of fleeces by breed, sex and age groups

	Number of fleeces from:											
	Yearling ewes			Mature ewes			Yearling rams			Mature rams		
Main sort	Ramb.	Targ.	Col.	Ramb.	Targ.	Col.	Ramb.	Targ.	Col.	Ramb.	Targ.	Col.
Fine Staple	322	36	11	639	46		132	50		97	2	2
Fine French	79			602			46			15	1	
1/2 Staple		161	47	22	195	8	1	93	13	15	23	
1/2 French				2	3							
3/8 Staple		21	105		117	207		16	99	1	33	11
3/8 French					2	2						
50's		2	12		12	163			27		2	13
48's						36			1			4
46's						3						3
Total	401	220	175	1265	375	419	179	159	140	128	61	33

1951 Wool Sorting Summary* - Ewes

Description	No. of fleeces contri- buting	Weight of wool sorted	Ave. wt. per fl. contri- buting	Percent of wool sorted	No. of fleeces contri- buting	Weight of wool sorted	Ave. wt. per fl. contri- buting	Percent of wool sorted
	Rambouillet Yearling Ewes				Rambouillet Mature Ewes			
Fine Staple	379	2245.7	5.93	64.83	941	6096.6	6.48	46.09
Fine French	394	985.3	2.50	28.44	1166	6185.9	5.31	46.76
1/2 Staple	13	8.1	.62	.23	42	228.1	5.43	1.72
1/2 French	7	2.9	.41	.08	91	80.4	.88	.61
3/8 Staple					1	1.5	1.50	.01
3/8 French					2	1.1	.55	
Offsorts	393	221.9	.56	6.41	1091	634.1	.58	4.79
Total	401	3463.9	8.64	99.99	1265	13277.7	10.46	99.98
	Targhee Yearling Ewes				Targhee Mature Ewes			
Fine Staple	46	264.7	5.75	13.17	57	422.0	7.40	10.10
Fine French	36	20.1	.59	1.00	41	25.2	.61	.60
1/2 Staple	194	1103.8	5.69	54.90	228	1746.1	7.66	41.80
1/2 French	93	50.7	.55	2.52	178	136.8	.77	3.27
3/8 Staple	170	355.6	2.09	17.69	241	1364.6	5.83	32.66
3/8 French	14	8.1	.59	.40	165	153.3	.93	3.67
50's	45	42.7	.95	2.12	82	161.8	1.97	3.87
48's	1	2.1	2.10	.10	10	7.2	.72	.17
46's					2	.7	.35	.02
Offsorts	217	162.6	.75	8.09	308	159.9	.52	3.83
Total	220	2010.4	9.14	99.99	375	4177.6	11.14	99.99
	Columbia Yearling Ewes				Columbia Mature Ewes			
Fine Staple	16	78.6	4.91	4.83				
Fine French	29	15.8	.54	.97	1	.6	.60	.01
1/2 Staple	65	320.2	4.93	19.67	10	76.1	7.61	1.52
1/2 French	44	20.8	.47	1.28	9	6.1	.68	.12
3/8 Staple	151	782.0	5.19	48.04	270	1979.0	7.33	39.57
3/8 French	44	31.9	.73	1.96	71	61.7	.87	1.23
50's	94	168.6	1.81	10.36	367	2052.8	5.59	41.05
48's	8	4.1	.51	.25	120	457.4	3.81	9.15
46's					15	54.6	3.64	1.09
Offsorts	174	205.7	1.18	12.64	395	312.8	.79	6.25
Total	175	1627.7	9.30	100.00	419	5001.1	11.94	99.99

* This summary does not include T_1, K_2 or miscellaneous groups.

1951 Wool Sorting Summary* - Rams

Description	No. of fleeces contri-buting	Weight of wool sorted	Ave. wt. per fl. contri-buting	Percent of wool sorted	No. of fleeces contri-buting	Weight of wool sorted	Ave. wt. per fl. contri-buting	Percent of wool sorted
	Rambouillet Yearling Rams				Rambouillet Mature Rams			
Fine Staple	170	1255.4	7.38	61.42	111	1233.9	11.12	62.67
Fine French	178	690.4	3.88	33.78	115	361.7	3.15	18.37
1/2 Staple	21	24.6	1.17	1.20	28	223.5	7.98	11.35
1/2 French	1	.4	.40	.02	28	34.6	1.24	1.76
3/8 Staple					5	19.5	3.90	.99
3/8 French					6	6.8	1.13	.35
Offsorts	165	73.2	.44	3.58	115	88.9	.77	4.52
Total	179	2044.0	11.42	100.00	128	1968.9	15.38	100.01
	Targhee Yearling Rams				Targhee Mature Rams			
Fine Staple	58	438.1	7.55	23.77	3	24.0	8.00	2.49
Fine French	52	42.9	.83	2.33	3	15.8	5.27	1.64
1/2 Staple	131	834.3	6.37	45.23	27	264.8	9.81	27.46
1/2 French	77	55.8	.72	3.03	8	6.4	.80	.66
3/8 Staple	105	292.0	2.78	15.84	54	490.1	9.08	50.82
3/8 French	11	8.9	.81	.48	26	18.4	.72	1.91
50's	9	11.9	1.32	.65	25	68.1	2.72	7.06
48's					2	2.3	1.15	.24
Offsorts	157	159.5	1.02	8.65	61	74.4	1.22	7.72
Totals	159	1843.4	11.59	99.98	61	964.3	15.81	100.00
	Columbia Yearling Rams				Columbia Mature Rams			
Fine Staple					2	22.5	11.25	4.00
Fine French					1	3.1	3.10	.55
1/2 Staple	26	124.3	4.78	7.32	1	1.1	1.10	.20
1/2 French	18	12.3	.68	.72				
3/8 Staple	123	926.8	7.53	54.58	15	138.5	9.23	24.61
3/8 French	55	39.9	.73	2.35	4	4.0	1.00	.71
50's	107	372.7	3.48	21.95	24	226.4	9.43	40.23
48's	26	32.8	1.26	1.93	13	81.9	6.30	14.55
46's	2	3.0	1.50	.18	5	38.5	7.70	6.84
Offsorts	140	186.4	1.33	10.98	33	46.8	1.42	8.31
Total	140	1698.2	12.13	100.01	33	562.8	17.05	100.00

* This summary does not include T_1, K_2 or miscellaneous groups.

Total Weights and Percentages of Various Sorts of Wool for 1950 and 1951

	1950		1951	
	Total weight (lbs.)	Percent of clip	Total weight (lbs.)	Percent of clip
Matchings				
Fine Staple	11,568.5	30.72	12,824.8	28.06
Fine French	3,586.5	9.52	8,467.1	18.53
1/2 Staple	4,555.2	12.09	6,563.2	14.36
1/2 French	1,035.4	2.75	578.6	1.27
3/8 Staple	4,381.9	11.63	7,642.5	16.72
3/8 French	781.0	2.07	549.5	1.20
50's	2,911.4	7.73	3,784.9	8.28
48's	2,493.3	6.62	795.6	1.74
46's	833.0	2.21	109.1	.24
Total Matchings	32,146.2	85.35	41,315.3	90.40
Offsorts				
Seedy-Stain				
60's & Finer	2,584.2	6.86	1,898.1	4.15
58's & Coarser	1,398.1	3.71	979.1	2.14
Tags - All grades	268.5	.71	179.9	.39
Crutchings - Rambouillet	664.0	1.76	665.0	1.46
Crutchings - Crossbred	602.0	1.60	665.0	1.46
Total Offsorts	5,516.8	14.65	4,387.1	9.60
Total Weight	37,663.0		45,702.4	

PRELIMINARY ANALYSIS OF FLEECE SORTING RESULTS FROM 1951 AND 1952 MATURE EWE FLEECES

Some results are summarized for mature ewes of the Rambouillet, Targhee and Columbia breeds for 1951 and 1952. In 1952, 56 percent of Rambouillet mature ewe wool was sorted into Fine Staple, 39 percent into Fine French, 1 percent into 1/2 Blood Staple and 4 percent into Seedy and Stained. This represents an increase from 46 percent of Fine Staple in 1951 and a decrease from 47 percent of Fine French in 1951. In 1952, 10 percent of Targhee mature ewe wool was sorted into Fine Staple, 1

percent into Fine French, 41 percent into 1/2 Blood staple, 33 percent into 3/8 Blood Staple, 1 percent into 3/8 Blood French, 5 percent into 50's and 9 percent into Seedy and Stained. This represents a decrease from 1951 in the percentages sorted into the French Combing lots and an increase in the percentage sorted into Seedy and Stained. In 1952, 1 percent of Columbia mature ewe wool was sorted into 1/2 Blood Staple, 35 percent into 3/8 Blood Staple, 39 percent into 50's 14 percent into 48's, 2 percent into 46's and 9 percent into Seedy and Stained. These proportions are similar to those for 1951 except for decreases in 3/8 Blood Staple and 50's and increases in 48's and Seedy and Stained. In all three breeds there was a slight tendency for the weight of Seedy and Stained wool per fleece to increase as the grade of wool became coarser.

These data for mature ewe fleeces in 1951 and 1952 were also summarized according to the number of sorts (matchings only) into which each fleece was divided. Of Rambouillet fleeces, 32 percent were placed in only one sort, 64 percent in 2 sorts and 4 percent in 3 sorts. Of Targhee fleeces, 7 percent were placed in one sort, 58 percent in 2 sorts, 31 percent in 3 sorts and 4 percent in 4 sorts. Of Columbia fleeces, 15 percent were placed in 1 sort, 70 percent in 2 sorts and 15 percent in 3 sorts. In Fine-Staple Rambouillet fleeces, those fleeces divided into 1 and 2 sorts were lighter than those divided into 3 and 4 sorts. In 1/2 Blood and 3/8 Blood Targhee fleeces those fleeces divided into 1 and 2 sorts were heavier than those divided into 3 and 4 sorts. This was also true of Columbia fleeces in grades of 3/8 Blood, 50's and 48's. A tendency was noted in Fine-Staple Rambouillet, 1/2 Blood and 3/8 Blood Staple Targhee, and in 3/8 Blood Columbia fleeces for the weight of offsorts per fleece to decrease as the number of sorts per fleece increased.

A preliminary study has been made of the relation of fleece sorting information to fleece value of mature ewe fleeces in 1951 and 1952. Within a fleece grade, fleece value tended to be associated with fleece weight regardless of the number of sorts. Within an entire breed, no definite relationships between fleece value and fleece weight or fineness were evident, possibly due to the interaction between price per pound, staple length, fineness and weight. However, in all three breeds, fleeces of Staple-Combing lengths were definitely more valuable than those of French-Combing lengths. Further studies are being made on the factors affecting fleece value to determine their merit as guides to a breeding and selection program.

PROCESSING STUDIES ON 1951 CLIP

Approximately 36,000 pounds of grease wool were used in cooperation with the Wool Division, Livestock Branch, Production and Marketing Administration, for studies of the commercial values of sorted wools. These wool sorts were processed into top by a commercial scouring and combing company. The accompanying table is a summary of the processing of each lot from the 1951 clip into top, noil and waste.

Summary From Processing Each Lot From 1951 Clip*

Description	Grease net weight	Scoured weight 14% MC**	Clean yield percent	Top weight 15% MC	Noil weight	Waste weight	Top percent	Noil percent	Noil % of Top and Noil
Fine Staple	10,600	5,242	49.45	4,201	670.0	251.5	39.63	6.32	13.75
Fine French	8,316	3,531	43.13	2,603	434.0	550.0	31.30	5.22	14.29
1/2 Staple	3,647	1,857	50.95	1,532	180.0	119.5	42.01	4.94	10.51
3/8 Staple	5.684	3,028	53.27	2,619	260.5	165.5	46.08	4.58	9.05
50's	3,557	2,067	58.11	1,742	137.0	108.8	48.97	3.85	7.29
48's & 46's	830	450	54.22	430	37.5	32.0	51.81	4.52	8.02
Seedy-Stain 60's and Finer	1,578	707	43.53	416	111.0	160.0	26.36	7.03	21.06
Seedy-Stain 58's and Coarser	834	429	48.56	292	30.0	83.0	35.01	3.60	9.32
Crutching - Rambouillet	665	236	36.69	138	44.0	62.0	20.75	6.62	24.18
Crutching - Crossbred	665	246	38.12	169	27.0	57.5	25.42	4.06	13.78

* Part of the wool from some lots was removed for other research before processing each lot.

** MC = Moisture Content

PROCESSING WOOL AT BELTSVILLE FROM INDIVIDUAL TARGHEE FLEECES

Following the annual sheep shearing of 1951 at the U. S. Sheep Experiment Station, Dubois, Idaho, the wool of each fleece was graded and sorted into matchings and off sorts. These sorted wools from 318 fleeces of Targhee sheep were sent to Beltsville, Maryland, for processing research. Fifty staples, or locks, of wool were systematically taken from the main sort (largest matching) of each of 220 Targhee yearling ewe fleeces, 68 Targhee yearling ram fleeces, and from 30 Targhee two-year-old ram fleeces after they were received at Beltsville. They were then individually dry cleaned, carded and stored at Beltsville for future combing. Average data for percentage of clean scoured yields of wool and for percentage of card sliver yields on the basis of the weights of clean scoured wool are reported in the following statement for these fleeces which were sheared at Dubois in 1951.

For Targhee yearling ewes the clean scoured wool yields averaged 49.2 percent for matchings grading 64's and finer, 52.3 percent for 60/62's and 56.7 percent for 56/58's. Of these same matchings the percentage of card sliver on a scoured wool basis averaged 88.5 percent for 64's and finer, 88.3 percent for 60/62's and 88.2 percent for 56/58's.

For Targhee yearling rams the clean scoured wool yields averaged 48.2 percent for matchings grading 64's and finer, 51.4 percent for 60/62's and 53.3 percent for 56/58's. On the same matchings the percentage of card sliver yield, on scoured wool basis, averaged 85.2 percent for 64's and finer, 88.3 percent for 60/62's and 86.7 percent for 56/58's.

For two-year-old Targhee rams the clean scoured wool yields averaged 47.9 percent for matchings grading 60/62's and 53.8 percent for 56/58's. On the same matchings the percentage of card sliver yield, scoured wool basis, averaged 87.3 percent for 60/62's and 86.1 percent for 56/58's. The fleeces from two-year-old rams were included in this study primarily for determining the repeatability of fleece processing traits. These data have been collected and are scheduled for analysis next year.

For the second consecutive year of this project, the average card sliver yield for yearling rams has run consecutively lower than that for yearling ewes. This may be due, at least in part, to differences in environmental conditions under which these two groups of sheep have been raised after weaning.

Work is progressing satisfactorily on the combing of the matchings from individual fleeces of Targhee rams and ewes of the 1950 clip from the U. S. Sheep Experiment Station, Dubois, Idaho. A repeatability test was run on the French Comb, using Rambouillet ram wool, U. S. Grade 60/62's. This wool, which had been scoured by the soap and soda ash method and carded on the worsted card at Beltsville, was separated into four lots for combing with the following average results: ratio of tops to noils, 10.1; percentage of tops, 90.04; percentage of noils, 8.91, making a total yield of tops and noils of 98.95 percent.

The following table shows the average results obtained from 130 Targhee fleeces of the 1950 Dubois clip which have been combed at Beltsville:

	Percent tops	Percent noils	Tear (Ratio of tops to noils)
Rams			
U. S. Grade 60's	86.27	10.78	8:1
U. S. Grade 62's	87.16	10.17	9:1
U. S. Grade 64's	88.22	9.24	10:1
Ewes			
U. S. Grade 60's	88.71	8.78	11:1
U. S. Grade 62's	87.57	10.27	9:1
U. S. Grade 64's	86.89	11.43	8:1

These results indicate considerable variation in the fleeces of individual sheep, since tear varies from 5:1 to 14:1 in the ewe fleeces and 3:1 to 18:1 in the ram fleeces. Further work which is now in process will have to be completed before any conclusions may be drawn from the combing operation. The U. S. Grades used in presenting the results of the combing of the Targhee fleeces are based on the cross-sectional work done at Dubois, Idaho.

COOPERATIVE WORK WITH THE FOREST SERVICE

Range plant growth in relation to weather

Recent analyses of plant growth and weather records at this Station have shown that response of vegetation is rather closely related to variations in precipitation and temperature. During a 16-year study period, early stages of plant development were negatively correlated with temperature of the growing season. Average date at which flower stalks appeared and March-April mean temperature produced a significant correlation coefficient (-.619), and the correlation of full bloom with March-May mean temperature was highly significant (r = -.927). Plant development during the latter part of the growing season, however, was more closely related to precipitation.

Height growth of range plants was also closely related to temperature. Past experience has shown that ranges in this locality are ready to graze each spring when bluebunch wheatgrass reaches a height of 2 1/2 inches; therefore, attempts were made to relate date this height was attained to snow melt and temperature. Although it was not closely related to snow melt (r = .437), this date, which averaged April 25 during the 16-year period, was highly correlated with March-April mean temperature (r = -.909)

and with mean temperature of March (r = -.813). Since it is important to know the date of range readiness a few weeks in advance, March temperature has the most practical value for predicting this date even though correlation with March-April temperatures was highest. The regression equation for estimating date of range readiness from temperature is: $Y = 65.86 - 1.39X$ in which Y equals number of days after March 31 and X equals March mean temperature.

Correlation analysis was also used to show the relation of yield to precipitation and temperature. In order to minimize the possibility of overlooking significant relationships, a large number of correlation coefficients were computed between yield of the different classes of vegetation and precipitation and temperature of the various seasons. Even though many of these were not statistically significant, it is noteworthy that in most cases correlation with precipitation was positive and with temperature was negative.

Correlation coefficients between precipitation of the July to March period immediately preceding the growing season and yield of grasses, forbs, shrubs, total, and combined grasses and forbs were .787**, .920**, .531, .810**, and .900**, respectively. Correlations of precipitation during the growing season with herbage yield were not significant except in the case of shrubs (r = .701*). Apparently moisture available at the beginning of the growing season has more effect on subsequent yield than does that which falls during the active period of growth.

Although none of the correlation coefficients between mean temperature and yield were significant, a number of relationships are apparent. The fact that all correlations between yield and mean temperatures during the spring were negative indicates that high temperatures were often associated with low yields. This same situation occurred, though to a lesser extent, for the July to September period preceding the growing season, but for the October to March period, a positive correlation was indicated. Generally, then,highest herbage yields were associated with relatively cool temperatures in July through September preceding the growing season, warmer than average temperatures during October through March, and cool temperatures during the growing season, April through June.

The close correlation of early plant growth and development with temperature offers a usable method of predicting the opening date of grazing each season. Also, the correlation of precipitation prior to the growing season with herbage yield allows a fairly accurate prediction of current forage production and provides a basis for estimation of sheep grazing capacity.